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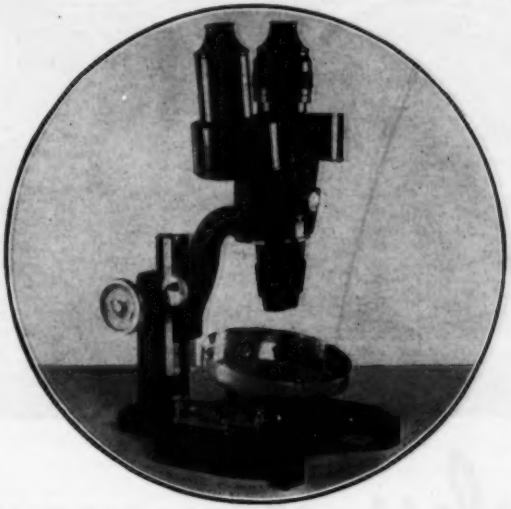

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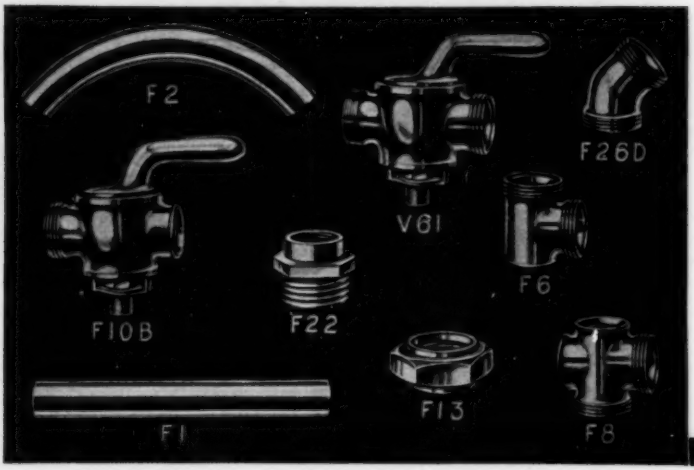

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JOURNAL OF DAIRY SCIENCE

VOLUME XIX JUNE, 1936 NUMBER 6

THE QUANTITIES OF GRASS THAT DAIRY COWS WILL GRAZE

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In order to determine how much, if any, supplementary feed should be fed to dairy cows on pasture it is important to know how much grass they will likely graze and the quantity of nutrients they will obtain from the grass.

Observations by the Bureau of Dairy Industry at Beltsville, Md., over a period of years showed that, with the system of feeding practiced there, cows decline rapidly in milk flow early in the summer while the grass is still fairly abundant; also that cows producing 1 pound of butterfat or less a day on pasture apparently maintain their production and body weight for a short time in the spring as well without grain feeding as with grain feeding.

In an investigation (1) at the Bureau's field station at Huntley, Mont., four Holstein-Friesian cows were fed grass clipped from irrigated pastures, for periods of 15 to 55 days. The average daily consumption by individual cows for an entire period varied from 122 pounds for the smallest cow to 152 pounds for the largest cow. The maintenance of milk flow and body weight indicated that these cows consumed enough grass to support a milk production of 37 pounds a day.

While one might be justified in assuming that cows will graze as much grass as they will eat out of a manger, provided the grass is sufficiently tender and abundant so they can gather their fill with little effort, it seemed that the truth of this assumption could be determined only by actual grazing trials.

The investigation reported in this paper, therefore, was undertaken to find out how much grass cows would graze, when grass was present in various degrees of abundance, both when the weather was cool and when it was warm. With this information it was hoped that a satisfactory explanation would be found for the behavior of cows on pasture and that a foundation could be laid for a better feeding system.

Received for publication January 18, 1936.

PLAN OF THE INVESTIGATION

The method of arriving at the quantity of grass cows will graze was to pasture cows on a certain area of grass for a given time. The cows were then removed and the remaining grass was clipped as low or lower than that where the cows had grazed. At the same time an area of similar pasturage which had not been grazed was clipped, and the difference between the quantities of clipped grass from the two areas was considered equivalent to the quantity of grass the cows obtained by grazing.

Twelve grazing trials were made in 1932, and three in 1933. Two cows grazed in each trial, from 2 to 4 days. Both Jersey cows and Holstein-Friesian cows were used.

It was considered important that the trials be made under normal grazing conditions, as nearly as possible. For that reason the cows were confined on the areas to be grazed, by fences instead of by tethering them. Two cows were placed on the same area because it was believed that two cows together would be more contented than one cow by herself. Good producing, vigorous cows were used since it was desired to have individuals that had both a demand for a large quantity of grass and an ability to graze a large quantity.

The pasture in which the trials were made was bounded on two sides by parallel fences 314 feet apart. Temporary fences were run from one side of this pasture to the other to enclose the strips to be grazed, also strips to be kept ungrazed. The grazed strips varied in size from 0.30 to 0.58 acre; the ungrazed strip alongside was usually 0.15 acre.

In order that the cows might start each grazing trial with a normal fill, they were kept for 2 days preceding each trial (in the same field as the fenced-off area) on grass similar to that to be grazed. No grain or other feed was given to the cows, either during the 2-day preliminary period or while they were grazing in the trial.

Water was provided in the pasture but no shade of any kind. During each trial the cows were on the grazing plot day and night and were taken off only long enough to be milked. After the cows had grazed in each trial the allotted time, 2 to 4 days, the fences were removed and each plot was clipped separately.

The original plan was to use a power lawn mower to clip these plots, and to facilitate the mowing the ground was smoothed with a roller early in the spring. It was found, however, that a farm mower could be used (by removing the shoes and setting it to cut as low as possible) to clip the grass fully as short as the cows had grazed. The clippings were collected in a galvanized-iron pan attached to the rear of the cutter bar.

The grass clipped from each plot was weighed separately and analyzed for feed nutrients. The difference between the amount of nutrients from

the ungrazed and the grazed areas represented the nutrients consumed. Digestion coefficients applied to these amounts indicated the digestible nutrients consumed. The coefficients used were the averages between those obtained by feeding green grass to dairy cows at the Pennsylvania, Vermont, and Beltsville, Md., Stations (3). These coefficients were 73.9 for crude protein, 53.6 for ether extract, 76.6 for nitrogen-free extract, and 73.7 for crude fiber.

COWS USED

Six of the 12 trials in 1932 were with Holstein cows, and 6 were with Jersey cows. Of the 3 trials in 1933, 1 was with Jerseys and 2 were with Holsteins.

In the 1932 trials with Holsteins, the same two cows were used throughout the season, one being a grade cow and the other a registered cow. The first trial was from May 22 to May 24. The grade cow had calved March 18, and the registered cow April 23, 1932. Previous to the first trial the grade cow had been on pasture since April 16 and the registered cow since April 28. The grade cow was also getting 8 to 12 pounds of grain a day and the registered cow 6 to 10 pounds. Between trials during the rest of the season these two cows were each fed 10 to 12 pounds of grain a day. The object of the grain feeding was to maintain the production so that when these cows were put on the experimental grazing plots they would have a demand for a large quantity of grass. By keeping up the production of these two cows it was not necessary to make any replacements.

In the 1933 Holstein trials, two grade cows were used in the first trial, April 24–27. One of these had calved September 8, 1932, the other February 18, 1933. Both had been on pasture since April 16 and had been getting 5 to 7 pounds of grain a day. In the next trial, July 8–12, a grade cow and a registered cow were used. They had calved June 12 and June 18, respectively, and had been fed 10 to 12 pounds of grain a day immediately prior to the trial.

In all trials with Jersey cows, only registered cows were used. In 1932, one of the cows used in the May trials had calved March 7, the other April 21. One had been on pasture since April 19, the other since April 27. Neither had received any grain since May 1.

One of these cows was disposed of after the May trials, and her place was taken by another Jersey for the rest of the 1932 trials. This cow had calved March 4, 1932. The Jersey cows were fed from 10 to 16 pounds of grain while on pasture between trials.

One of the Jersey cows in the trial of April 24–27, 1933, had been used in all 1932 trials. She had calved again January 30, 1933, and had been fed 2 to 6 pounds of grain from the time she was turned on pasture, April 16. The other cow had calved November 29, 1932, and had received 4 to 5

TABLE 1

Composition of the green grass clipped from the different grazed and ungrazed plots, and the breed used in the grazing trial

DATE CLIPPED	BREED USED IN TRIAL	PLOT	DRY MATTER	DRY MATTER BASIS						
				Protein	Ether extract	Ash	Nitrogen-free extract	Crude fiber	Calcium	Phosphorus
1932			*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
5–18	Jer.	Grazed	19.6	19.9	4.5	10.8	38.3	26.6	0.67	0.41
5–18		Ungrazed	18.2	22.4	4.9	11.2	37.8	23.7	0.73	0.44
5–20	Jer.	Grazed	21.8	15.9	4.2	9.9	41.7	28.3	0.66	0.41
5–20		Ungrazed	19.6	18.8	5.0	10.0	40.8	25.4	0.64	0.42
5–24	Hol.	Grazed	22.7	14.2	3.9	9.2	43.7	28.9	0.53	0.38
5–24		Ungrazed	20.7	17.0	4.8	9.8	43.8	24.7	0.70	0.39
5–26	Hol.	Grazed	23.2	14.8	4.3	10.3	40.2	30.4	0.60	0.44
5–26		Ungrazed	21.9	15.5	4.5	9.2	43.1	27.7	0.72	0.38
6–24	Jer.	Grazed	24.5	18.9	4.7	9.7	40.2	26.5	0.82	0.48
6–24		Ungrazed	22.7	20.8	4.5	9.8	38.8	26.1	0.76	0.48
6–24	Hol.	Grazed	23.2	19.1	3.7	10.0	39.7	27.5	0.80	0.48
6–29	Jer.	Grazed	25.5	17.4	4.0	9.7	40.1	28.7	0.76	0.51
6–29		Ungrazed	23.2	20.0	4.9	10.1	38.2	26.8	0.66	0.49
6–29	Hol.	Grazed	24.9	17.2	3.9	9.7	40.0	29.3	0.79	0.46
8–16	Jer.	Grazed	38.0	14.8	5.1	8.9	45.5	25.7	0.95	0.40
8–16		Ungrazed	39.8	17.2	5.4	7.5	46.3	23.6	1.14	0.36
8–16	Hol.	Grazed	44.5	14.1	4.4	8.4	48.0	25.2	1.13	0.34
8–19	Jer.	Grazed	35.0	14.3	5.0	8.6	45.5	26.6	0.96	0.35
8–19		Ungrazed	29.0	15.0	5.0	8.9	45.4	25.7	0.78	0.38
8–19	Hol.	Grazed	29.5	14.8	4.3	9.0	44.5	27.4	0.87	0.35
1933										
4–27	Jer.	Grazed	23.3							
4–27		Ungrazed	23.0							
4–27	Hol.	Grazed	23.2							
7–12	Hol.	Grazed	27.3							
7–12		Ungrazed	25.4							

TABLE 2

The quantities of grass and of nutrients consumed by grazing—average per cow per day[1]

DATES	BREED	GREEN WEIGHT OF GRASS	TOTAL DRY MATTER	NUTRIENTS IN DRY MATTER						
				Crude protein	Ether extract	Ash	Nitrogen-free extract	Crude fiber	Calcium	Phosphorus
		Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1932:										
May 16–18	Jer.	136	23.5	5.6	1.2	2.7	8.8	5.1	0.18	0.11
May 18–20	Jer.	167	31.6	6.2	1.8	3.2	12.8	7.7	0.20	0.13
May 22–24	Hol.	147	28.9	5.4	1.5	2.9	12.7	6.4	0.23	0.11
May 24–26	Hol.	152	31.9	5.1	1.4	2.7	14.5	8.2	0.26	0.10
June 22–24	Jer.	98	20.5	4.7	0.8	2.0	7.6	5.2	0.14	0.10
June 22–24	Hol.	32	6.5	2.0	0.6	0.5	2.2	1.1	0.03	0.03
June 26–29	Jer.	98	20.6	4.7	1.2	2.2	7.4	3.0	0.11	0.09
June 26–29	Hol.	109	23.9	5.4	1.4	2.5	8.7	3.8	0.13	0.12
Aug. 14–16	Jer.	34	14.2	2.7	0.8	0.9	6.6	3.1	0.18	0.05
Aug. 14–16	Hol.	50	19.5	3.5	1.1	1.4	8.9	4.5	0.22	0.07
Aug. 17–19	Jer.	61	15.2	2.4	0.8	1.4	6.8	3.7	0.09	0.06
Aug. 17–19	Hol.	50	14.3	2.2	0.8	1.2	6.6	3.4	0.09	0.06
1933:										
Apr. 24–27	Jer.	148	33.9							
Apr. 24–27	Hol.	154	35.3							
July 8–12	Hol.	146	34.1							

[1] In 1933 chemical analyses were made only for moisture.

TABLE 3

Average daily consumption of grass, dry matter, and total digestible nutrients per cow; the quantity of nutrients available for milk production in excess of the nutrients required for maintenance; and the quantity of milk production the excess nutrients would support

DATE OF TRIAL	DESCRIPTION OF PASTURAGE					AIR TEMPERATURE		BREED OF COWS	AVERAGE WEIGHT OF COWS	AVERAGE PRODUCTION		AVERAGE DAILY CONSUMPTION PER COW			T.D.N. AVAILABLE FOR MILK PER COW PER DAY OVER THE AMOUNT REQUIRED FOR MAINTENANCE	MILK PRODUCTION PER COW PER DAY WHICH THE EXCESS NUTRIENTS WOULD SUPPORT
	Kind	Height	Herbage per acre			Maximum	Minimum			Milk	Butterfat	Green grass	Dry matter	T.D.N.		
			Green weight	Dry matter												
1932:		*Inches*	*lbs.*	*Per cent*	*lbs.*	*° F.*	*° F.*		*lbs.*	*lbs.*	*Per cent*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
May 16–18	Orchard grass, white clover	6 to 8	2,850	18.19	518	87	52	Jer.	1,141	28.2	4.82	136	23.5	16.1	7.0	18
May 18–20	do	6 to 8	2,980	19.56	583	69	40	Jer.	1,141	27.7	4.66	167	31.6	22.2	13.2	34
May 22–24	do	6 to 10	3,113	20.73	645	73	43	Hol.	1,432	45.3	3.01	147	28.9	20.2	8.9	31
May 24–26	do	6 to 10	3,669	21.90	804	86	44	Hol.	1,432	44.8	3.01	152	31.9	22.6	11.3	39
June 22–24	Orchard grass, white clover, lespedeza	2 to 6	1,400	22.70	318	90	66	Jer.	993	26.4	4.51	98	20.5	14.1	6.2	16
June 22–24	do	2 to 6	1,400	22.70	318	90	66	Hol.	1,381	37.6	3.50	32	6.5	4.7	−6.2	−20
June 26–29	do	3 to 8	1,986	23.19	461	91	62	Jer.	993	24.5	4.51	98	20.6	12.8	4.9	13
June 26–29	do	3 to 8	1,986	23.19	461	91	62	Hol.	1,381	33.4	3.46	109	23.9	15.1	4.2	13
August 14–16	Orchard grass, lespedeza	2 to 6	861	39.84	343	88	51	Jer.	1,034	22.2	4.70	34	14.2	10.3	2.1	5
August 14–16	do	2 to 6	861	39.84	343	88	51	Hol.	1,444	30.7	2.50	50	19.5	14.1	2.6	10
August 17–19	Orchard grass, lespedeza, and some foxtail	2 to 6	1,437	29.07	418	90	63	Jer.	1,034	21.3	4.66	61	15.2	10.7	2.5	6
August 17–19	do	2 to 6	1,437	29.07	418	90	63	Hol.	1,444	27.0	2.73	50	14.3	10.2	−1.3	−5
1933:																
April 24–27	Orchard grass, white clover	6 to 8	3,967	23.00	915	71	29	Jer.	1,036	21.3	4.51	148	33.7	23.3	15.1	40
April 24–27	do	6 to 8	3,967	23.00	915	71	29	Hol.	1,232	33.7	3.59	154	35.2	24.3	14.5	45
July 8–12	Orchard grass, lespedeza, and a little white clover	6 to 8	5,652	25.38	1,434	88	60	Hol.	1,369	41.5	3.65	146	34.1	23.6	12.7	39

pounds of grain a day from the time she was turned on pasture, April 14, to the beginning of the trial.

RESULTS

The analyses[1] of the green grass from the different grazed and ungrazed plots are given in table 1.

The quantities of green material and of the nutrients consumed by the grazing cows are shown in table 2.

Table 3 contains a description of the pasturage, the cows and their production, and gives the maximum and minimum temperatures during the period of grazing; also a summary of the consumption of grass and nutrients, and an estimate of the quantities of milk for which the grass intake would provide the nutrients.

In May, 1932, when the grass was tender and abundant and the weather cool, Jersey cows in two trials ate an average of 151 pounds of green grass a day. The Holstein cows ate 149 pounds. This compared very well with the quantity consumed by cows at Huntley, Montana, when the grass was clipped and fed in the stable and is perhaps near the maximum quantity that cows will consume. The quantity of dry matter consumed by the Jerseys was 27.5 pounds per cow per day on an average, while that consumed by the Holsteins was 30.4 pounds. The grass grazed by the Holsteins had a little higher percentage of dry matter than that grazed by the Jerseys.

The Jerseys ate an average of 19.1 pounds of digestible nutrients; the Holsteins 21.4 pounds. Deducting for maintenance at the rate of 7.925 total digestible nutrients for each 1,000 pounds of live weight, it appears that the Jersey cows, although actually producing an average of about 28 pounds of milk a day, ate only enough to support a production of 26 pounds and the Holstein cows, producing 45 pounds a day, ate only enough for about 35 pounds. During this period the quantity of grass each of the cows ate in a day on the average was 5.8 per cent of that standing on one acre.

After these trials in May the pasture was heavily grazed and then clipped in order to have a uniform growth for further trials in June.

The quantity of grass on the ground in June was only a little more than half that in May. The Jersey cows ate 98 pounds of grass a day in each of two trials; the Holstein cows ate 32 pounds a day in one trial and 109 in the other. No explanation is offered for the low consumption by the Holsteins in the first trial. So far as known, there was no error in the methods or in calculation. However, the estimate is so much at variance with the other estimates of consumption by the cows during June that its omission from consideration appears justified. If this is done, the Jerseys ate an average of 20.5 pounds of dry matter a day and the Holsteins 23.9 pounds.

[1] All chemical analyses were made by Charles B. Parker, junior chemist, Bureau of Dairy Industry.

The quantity of digestible nutrients consumed per day was 13.5 pounds for the Jerseys and 15.1 pounds for the Holsteins. After deducting for maintenance, it appears that the Jerseys ate enough grass for about 15 pounds of milk a day, although they actually gave 25 pounds. The Holsteins ate enough for 13 pounds of milk and they actually gave 33 pounds. The average quantity of grass consumed daily by each cow was 6.9 per cent of that standing on one acre.

The trials were repeated in the same way in August when the growth of grass was still less than in June. The Jersey cows ate an average of 47 pounds of grass a day in two trials and the Holstein cows an average of 50 pounds. The quantity of dry matter consumed by the Jerseys was 14.7 pounds; by the Holsteins 16.9 pounds.

The digestible nutrients consumed by the Jerseys amounted to 10.5 pounds a day; by the Holsteins 12.1 pounds. Allowing for maintenance the Jerseys ate enough for 5 or 6 pounds of milk and actually produced about 22 pounds. The Holsteins ate enough for only 2 or 3 pounds and actually produced about 29 pounds. The quantity of grass consumed daliy by each cow was 5.2 per cent of that standing on one acre.

The pasture was, of course, poorer in June than in May and still poorer in August; but even in August, it is believed, the pasture would have been rated fair to good; and it was probably better than the average run of pastures at that season of the year.

Late in April, 1933, the trials were again repeated with much the same result as in May, 1932. The grass was a little better than in the previous year. The Jersey cows ate 148 pounds of grass and the Holstein 154 pounds. The dry matter consumption was 33.7 and 35.2 pounds, respectively, and the consumption of digestible nutrients 23.3 and 24.3 pounds. Allowing for maintenance, this was enough for the production of 40 pounds of milk by the Jerseys and 45 pounds by the Holsteins. Actually the Jerseys gave 21 pounds and the Holsteins 34 pounds. The quantity of grass consumed daily per cow was 4.4 per cent of that standing on one acre.

Because of the unusually favorable season, the grass in July, 1933, was similar in composition to that in May. Although probably no taller than in May, 1932, or April, 1933, the grass was much thicker, which accounts for the higher yield per acre. Only Holstein cows were used in this last trial. They ate 146 pounds of grass per cow per day, or 34.1 pounds of dry matter and 23.6 pounds of digestible nutrients. This was enough in excess of maintenance requirements for the production of 39 pounds of milk. The cows actually produced 41.5 pounds. The quantity of grass consumed per cow per day was only 2.9 per cent of that standing on one acre.

In 1933 chemical analyses were made only for moisture. For this reason, the total digestible nutrients for the last three trials were estimated

from the twelve preceding trials in which the total digestible nutrients were found to be 69.09 per cent of the dry matter.

INFLUENCE OF AIR TEMPERATURE

The data presented in table 3 afford but little opportunity to make a direct comparison of the influence of different air temperatures on the quantity of grass the cows grazed, because in most cases the cooler temperatures were accompanied by more abundant pasturage. Probably the only data suitable for such a comparison are those from the trials with Holstein cows in April and July, 1933. Although there was somewhat more herbage on the ground in July than in April, it appears there was enough in April so the cows could graze their fill. The grass in July and April was similar in dry matter content and stage of maturity. The cows ate an average of 154 pounds of grass a day in April and 146 pounds in July. In April the maximum temperature was 71° F., and the minimum was 29°. In July the maximum was 88° and the minimum 60°. It appears from this one comparison that a warm temperature did not materially lessen the consumption of grass. However, it should be noted that the maximum temperature of 88° and the minimum of 60° for July lack somewhat of being as high as those frequently occurring during the summer season at Beltsville.

INFLUENCE OF BREED ON THE QUANTITY OF GRASS GRAZED

Both the Jerseys and Holsteins were heavier than the average for the breed. The average weight of the cows in the 7 comparative trials was 1,053 pounds for the Jerseys and 1,392 pounds for the Holsteins. The average quantity of green grass eaten a day was 106 pounds for the Jerseys and 110 pounds for the Holsteins. The average daily consumption of dry matter was 22.8 and 25.4 pounds, respectively. Possibly this difference in consumption can be best explained by the difference in the size of the two breeds as one would naturally expect large cows to eat more than small ones. The Jerseys, however, ate somewhat more than the Holsteins per unit of body weight.

QUANTITY OF MILK AND BUTTERFAT FOR WHICH THE GRAZED GRASS WOULD PROVIDE THE NUTRIENTS

If no allowance is made for the energy used in the act of grazing, the digestible nutrients consumed in May, 1932, in excess of the quantities required for maintenance, were enough on the basis of the Savage standard for the production of 26 pounds of milk and 1.23 pounds of butterfat a day by the Jerseys and 35 pounds of milk and 1.04 pounds of butterfat by the Holsteins. In June the Jerseys ate enough for 15 pounds of milk and .66 pound butterfat; the Holsteins enough for 13 pounds of milk and .45 pound

butterfat, if the one trial that was out of line is disregarded. In August the Jerseys ate enough for 5 or 6 pounds of milk and .26 pound of butterfat; the Holsteins enough for 2 or 3 pounds of milk and .06 pound butterfat. In April, 1933, the Jerseys ate enough for 40 pounds of milk and 1.80 pounds butterfat; the Holsteins enough for 45 pounds of milk and 1.72 pounds butterfat. Holsteins in the final trial in July, 1933, ate enough for 39 pounds of milk and 1.42 pounds of butterfat.

Calculations based on the Savage standard show that the quantity of digestible protein consumed by the cows was in every instance much in excess of that required for the production of the quantities of milk mentioned above. The phosphorus intake was also well above the quantities specified as necessary by Huffman (2) of the Michigan Agricultural Experiment Station. The calcium intake on the average was almost twice that of the phosphorus intake. Milk contains only about one-third more calcium than phosphorus. If it is assumed that the calcium and phosphorus ingested are equally well retained (and there is some justification for such an assumption (3)), then there was no deficiency of calcium. It appears that if a cow will eat enough immature grass to provide the required digestible nutrients and if this grass has a normal content of minerals, her ration is not likely to be deficient in any of the essential food constituents.

These trials show that cows will eat enough grass when the pasturage is at its best to produce well over a pound of butterfat a day. They also show that the pasturage may often become so sparse or short in midsummer as to provide no more than the maintenance requirement. The reason that cows lose flesh and decline rapidly in milk flow in the summer is apparently due almost entirely to a lack of sufficient feed.

PRACTICAL APPLICATIONS

These trials indicate that a cow will graze in a day about 6 per cent of the immature grass standing on 1 acre of ground, and that the limit of her capacity is about 150 pounds of grass a day; or perhaps it may be better stated as 30 to 35 pounds of dry matter, depending on her size. This means that the pasture would have to yield 2,500 or more pounds of grass to the acre, with a dry matter content of 20 per cent, to permit the cow to graze her fill.

There seems to be no practical way of determining and describing how good a pasture is. As a rule, it would be impossible to determine from the appearance of a pasture that cows would eat a certain amount of grass a day, or that the pasture would support a milk flow of a certain quantity, or that any definite quantity of supplementary feed would have to be supplied. Therefore, it is suggested that the cow herself be allowed to make up for any shortage of grass by permitting her to have all the hay or silage

or both that she will clean up at least once a day, throughout the grazing season. When the pasturage is good she will eat but little roughage, but when it is poor she will eat much more. If feeding is managed in this way, probably the intake of nutrients in pasturage and roughage combined will vary but little; and the grain allowance, if any, can be kept fairly uniform throughout the entire season. In any system of feeding one must be certain that the allowance of protein is ample. This proposed method of feeding and management needs to be confirmed by experimental work before it can be definitely advocated.

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VITAMIN D STUDIES IN CATTLE

IV. Corn Silage as a Source of Vitamin D for Dairy Cattle*

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In previous reports from this Station, experimental data have been submitted upon the antirachitic value of sun-cured hay for dairy cattle (1), the vitamin D sparing action of certain magnesium compounds when only small amounts of this vitamin were present in the dairy ration (2), and the essential nature of radiant energy in the dietary régime of the dairy calf (3). The present report is concerned with the antirachitic value of corn silage for dairy cattle.

Hess and Weinstock (4) reported that green plants grown in the dark contained no vitamin D but became antirachitic after ultraviolet irradiation. Bethke, Kennard and Kik (5) failed to prevent leg weakness in chicks when green, fresh red-clover was fed as 50 per cent of the ration. Steenbock and associates (6) found that clover hay cured in the dark was inactive antirachitically. Mellanby and Killick (7) reported that summer-grown grass contained more of the calcifying factor than cabbage. Green spinach grown in midsummer has been reported by Chick and Roscoe (8) to have a slight but appreciable antirachitic value. While an investigation regarding the actual feeding of fresh, green plants as a source of vitamin D to dairy cattle is lacking, the indications are that fresh, green pasture grasses, in general, are poor sources of antirachitic substances.

As previously indicated (1), the antirachitic potency of hays is related to their exposure to solar ultraviolet rays. It is the usual practice to harvest corn for silage when many of the ears have become dented, the bottom three or four leaves and a portion of the husk have become dry while the remainder of the plant is still green. Corn at this stage of maturity is mostly green plant substance and for this reason has been considered a poor source of vitamin D, although this point has not been specifically investigated. Because of the presence of sun-dried leaves, however, and other material

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on the plant at the time of ensiling, it was thought possible that corn silage might have an appreciable antirachitic value.

The object of this investigation was to determine the antirachitic value of corn silage for dairy cows.

EXPERIMENTAL

The corn silage was made from dent corn which was cut when the kernels were dented and the lower leaves were dry. One sample of silage was taken for each of the following years, 1931–1934, inclusive, for biological assay with rats. Each sample of silage was immediately put in a drying room at 50°–60° C. after collection and after about one week, the dried material was ground and stored in stoppered bottles at room temperatures until needed for assaying. The vitamin D content of the silage was determined by the curative feeding technique with rats according to a standard line-test procedure. The vitamin D contents of the silage, in terms of U. S. P. rat units, are shown in Table 1.

TABLE 1

Vitamin D content of silage, U. S. P. rat units

CURATIVE MATERIAL	UNITS PER POUND DRY MATTER*
Corn silage 1931	165
Corn silage 1932	122 –
Corn silage 1933	122
Corn silage 1934	165

* Air dried basis.

The nineteen grade-Holstein dairy calves of either sex which were used in this experiment were divided into 5 groups. The calves in the first 4 groups were placed on experiment at birth but the calves in group 5 were several months of age when placed on this experiment. The management of the calves and the composition of the rachitogenic calf ration were similar to that previously reported (1–3). Blood samples were obtained from each of the experimental calves every two weeks and the plasma from each sample was analyzed for calcium, inorganic phosphorus (9) and magnesium (10) by methods already recorded. At the time of post-mortem examination, certain bones were saved from each animal and studied histologically (11). The chemical analysis of the various feeds used in this investigation are given in Table 2.

The calves in Group I, C–140, C–161 and C–164, were fed the unsupplemented basal rachitogenic ration. The calves in Group II, C–135, C–139 and C–141, each received the ash from one pound of dry silage per day in addition to the basal ration. The calves in Group III, C–132, C–136, C–137,

TABLE 2

Chemical analysis of feeds and water

MATERIAL	MOISTURE	Ca	P	Mg
	per cent	*per cent*	*per cent*	*per cent*
Whole milk	.....	0.120	0.093	0.012
Skim milk	.....	0.122	0.096	0.012
Corn and oats	11.80	0.128	0.321	0.156
Grain mixture	11.30	0.494	0.364	0.199
Corn silage 1931–32*	76.61	0.175	0.062	0.122
Corn silage 1932–33	78.02	0.101	0.054	0.067
Corn silage 1933–34	70.51	0.103	0.054	0.088
Corn silage 1934–35	69.00	0.126	0.064	0.115
Corn silage ash	.....	7.190	2.950	6.770
Water	.....	0.0082	.....	0.0027

* Each year's analysis began with September.

C–138 and C–145, received from one to six pounds of silage per day per animal. Following the above curative feeding trials, the calves in Group IV, C–156, C–159 and C–160, were used in a preventive trial. The calves in this group received the basal ration but corn silage was added as the sole source of vitamin D when the calves were 30 days of age. The calves in the above groups which survived were slaughtered at approximately 190 days of age, with the exception of C–159 which was changed to another experiment.

Calves C–168, C–169, C–188, C–195 and C–167 were subsequently added to this experiment as Group V. The first four calves were rachitic at the time when silage was added to their basal rachitogenic ration. Calf C–168 was 269 days of age and had been suffering from rickets for about 50 days, calf C–169 was 348 days of age and had been suffering from rickets for about 100 days, calf C–188 was 428 days of age and had had rickets for more than 200 days and calf C–195 was 395 days of age and had had rickets for at least 60 days when silage was added to their rations. Calves C–168 and C–169 were subsequently slaughtered, C–188 died while on experiment and C–195 was continued on experiment to determine the effect of the ration upon growth and reproduction. Calf C–167 was normal when silage was added to the ration.

RESULTS

The results obtained from the experiment are presented in Tables 3–7, inclusive. Table 3 summarizes the data pertaining to the age when the calves were placed on experiment, the age when the supplement was added, the first evidence of rickets, the age of the calves at the termination of the experiment and the terminal plasma calcium, magnesium and inorganic phosphorus values. Table 4 gives the data for a representative animal in Groups I–IV, inclusive.

TABLE 3

Summary of data pertaining to calves which received the rachitogenic ration

CALF	EXPER. STARTED. AGE	SUPPLEMENT ADDED. AGE	RACHITIC. AGE	EXPER. ENDED. AGE	TERMINAL PLASMA		
					Ca	P	Mg
no.	*days*	*days*	*days*	*days*	*mg. per 100 cc.*		
Group I. Basal ration							
C–140	1	none	73	88 D[1]	9.4	13.80	2.33
C–161	1	"	127	162 D	9.3	9.06	2.19
C–164	1	"	108	158 D	8.8	6.69	1.87
Group II. Basal ration plus silage ash							
C–135	1	93	72	108 D	6.8	6.51	2.80
C–139	1	90	71	114 D	7.3	8.62	1.68
C–141	1	79	73	193 S[2]	8.4	5.84	2.43
Group III. Basal ration plus silage							
C–132	1	93	93	193 S	8.2	3 °1	2.00
C–136	1	95	81	191 S	8.6	3.68	2.45
C–137	1	92	67	192 S	8.6	3.50	.....
C–138	1	86	86	193 S	10.0	7.35	2.82
C–145	1	92	92	190 S	10.0	2.27	2.45
Group IV. Basal ration plus silage before the onset of rickets							
C–156	1	32	161	186 S	7.5	3.63	1.56
C–159	1	33	116	190[3]	–	–	–
C–160	1	30	95	193 S	8.0	3.01	1.80
Group V. Basal ration plus silage (older calves)							
C–167	192	192	none	1140[4]	...../	.....	.....
C–168	269	269	210	371 S	11.9	7.27	3.12
C–169	348	348	248	414 S	12.3	6.79	2.45
C–188	428	428	225	520 S	8.5	4.13	2.33
C–195	366	366	300	813[5]	.....	.....	.....

[1] D denotes died. [2] S denotes slaughtered. [3] Changed to another experiment. [4] Still on experiment. [5] Changed to another experiment, cow still alive.

Group I.—The three calves in this group received the unsupplemented basal ration. Anorexia was manifested by C–140 and C–161 after the onset of rickets and C–161 also had a convulsion at 162 days of age. C–164 had a severe convulsion at 128 days of age at which time 5 cc. of parathormone was injected subcutaneously. A mild convulsion was again noted at 157 days of age and the calf was found dead on the following day. The condition of the pen indicated that the calf had died in a convulsion.

Group II.—The three calves in this group had their basal rachitogenic ration supplemented with silage ash. C–135 contracted bilateral pneumonia

TABLE 4

Growth data, mineral and silage intakes and blood plasma values of representative calves

AGE	WT.	HT.	DAILY SILAGE INTAKE				AV. DAILY INTAKE			BLOOD PLASMA		
			Silage	D.M.	D.M. per kilo	Vit. D units	Ca	P	Mg	Ca	P	Mg
days	*lb.*	*cm.*	*lb.*	*lb.*	*gm.*	*U.S.P.*	*gm.*	*gm.*	*gm.*	*mg. per 100 cc.*		
Group I. C–161. Basal ration												
30	88	79					4.3	3.3	0.4	13.1	6.53	2.21
60	122	82					8.8	6.1	1.4	12.6	6.25	2.62
90	144	86					9.8	9.3	2.0	10.6	7.95	2.36
120	163	89					12.7	9.8	2.4	10.7	7.42	2.16
150	169	90					8.9	6.7	3.4	8.5	5.37	1.80
162[1]	.....	.....					.....	.....	.....	8.8	7.28	2.13
Group II. C–141. Basal ration plus silage ash												
70[2]	132	78					8.3	7.6	1.5	9.2	5.63	2.80
100	162	83					14.8	9.4	3.2	8.4	6.89	1.95
130[3]	192	87					14.2	10.1	4.8	7.1	6.38	1.85
160[3]	199	90					11.1	7.3	5.3	6.9	5.80	1.71
190[3]	202	91					11.0	7.3	5.3	7.8	5.11	2.03
193[4]	201	.....					.....	.....	.....	8.4	5.84	2.43
Group III. C–145. Basal ration plus silage												
100	188	85	2.1	0.5	2.6	60	14.2	10.2	3.7	9.5	4.66	2.58
130	239	89	5.6	1.3	5.7	159	19.3	12.8	7.1	10.3	3.10	2.29
160	277	92	6.0	1.4	5.4	171	17.1	9.9	7.8	11.4	3.11	2.60
190[4]	280	96	5.8	1.4	4.8	166	16.6	9.2	7.4	10.7	2.99	2.44
Group IV. C–159. Basal ration plus silage before the onset of rickets												
30[5]	102	77	.....	.....	.....	.....	4.6	3.5	0.5	12.1	6.55	2.41
60	123	80	.....	.....	.....	.....	8.5	7.0	1.1	11.9	6.60	2.36
90	152	84	0.7	0.2	1.3	19	10.0	9.1	2.2	11.7	5.82	2.21
120	184	88	1.0	0.2	1.4	27	13.7	10.3	3.0	9.9	7.25	2.37
150[6]	202	90	1.7	0.4	1.9	46	9.3	6.1	3.9	8.5	5.46	1.98
180	228	92	2.5	0.6	2.4	67	11.3	7.7	4.8	8.0	6.82	1.99
210[7]	229	.....	3.1	0.7	3.0	83	11.8	7.9	5.1	6.6	5.48	1.65

[1] Convulsion, died. [2] Added silage at 78 days of age. [3] Convulsions 129, 167, 183, and 184 days of age. [4] Slaughtered. [5] Added silage at 32 days of age. [6] Stiff at 166 days of age. [7] Convulsions at 198 days of age, injected 5 cc. of parathormone subcutaneously. Removed from experiment at 210 days of age.

and died at 108 days of age. C–139 had a convulsion at 88 days of age and died at 114 days of age. C–141 had convulsions at 129 and 167 days of age. Parathormone was injected after each convulsion. Convulsions were again noted at 183 and 184 days of age. The calf was slaughtered at 193 days of age.

Group III.—After 90 days of age, the five calves in this group received the basal ration supplemented with small amounts of silage. All of the calves showed the clinical evidences of rickets from 62 to 93 days of age. C–137 had convulsions at 83 and at 90 days of age. The corn silage supplement was started at 92 days of age and convulsions were observed at 128 days of age. The calves in this group were slaughtered at approximately 190 days of age. C–145 was representative of this group, therefore, the calcium, phosphorus and magnesium intakes and the concentration of these constituents in the blood plasma are presented in Table 4.

Group IV.—The three calves in this group had their ration supplemented with corn silage at about 30 days of age and before the onset of rickets. The calves did not develop rickets until they were from 95 to 161 days of age. They did not consume enough silage at an earlier age to prevent rickets but the silage consumption tended to delay the symptoms. As they became older an insufficient amount of silage was consumed to prevent rickets because of anorexia. C–156 and C–160 were slaughtered at about 190 days of age and C–159 was changed to another experiment at 210 days of age. The representative experimental data secured from C–159 are presented in Table 4.

Group V.—With the exception of C–167, the older calves which were used in this group to determine the antirachitic effect produced by the ingestion of large amounts of silage were rachitic when placed on experiment.

Calf C–167. This calf had previously been used to determine the efficacy of solar ultraviolet radiation in preventing the manifestations of rickets (3). Table 5 presents the growth data, feed consumption and blood plasma values from 210 days of age until the termination of the experiment. She received corn silage as the sole source of vitamin D at 192 days of age and ate it with avidity from the very beginning, grew normally and maintained a sleek appearance at all times. C–167 was first bred at 467 days of age and again at 487 and 515 days of age. She aborted at 601 days of age and was again bred at 662 and 765 days of age. Beginning at 920 days of age, all grain was withheld from the ration and corn silage was the sole source of food other than wood shavings, salt and water. This heifer gave birth to a normal 85-pound heifer calf at 1032 days of age and had a retained placenta. C–167 averaged approximately 45 pounds of milk per day, containing 3.5 per cent fat, during the first 100 days of lactation on a ration which consisted of the rachitogenic grain mixture, corn silage, wood shavings, salt and water. Pre-

TABLE 5

C–167. Growth data, mineral and silage intakes and blood plasma values[1]

AGE	WT.	HT.	DAILY SILAGE INTAKE				AV. DAILY INTAKE			BLOOD PLASMA		
			Silage	D.M.	D.M. per kilo	Vit. D units	Ca	P	Mg	Ca	P	Mg
days	*lb.*	*cm.*	*lb.*	*lb.*	*gm.*	*U.S.P.*	*gm.*	*gm.*	*gm.*	*mg. per 100 cc.*		
210	314	98	3.0	1.1	3.3	129	14.9	9.9	6.5	10.4	8.23	2.47
240	345	102	11.7	2.6	7.4	315	16.1	10.1	7.8	11.7	7.60	2.68
270	401	103	16.5	3.6	9.0	445	19.3	12.0	9.7	12.2	7.81	3.12
300	453	108	18.7	4.1	9.0	502	22.0	13.8	11.0	11.4	7.36	2.48
330	486	109	16.3	3.6	7.4	440	20.2	12.6	10.0	11.7	7.75	3.40
360	546	111	19.3	4.3	7.8	521	23.3	14.5	11.6	11.4	6.85	3.47
390	607	114	20.0	4.4	7.2	539	23.7	14.8	11.9	12.3	7.60	3.09
420	645	117	20.0	4.4	6.8	539	23.8	14.8	11.9	11.9	7.24	3.33
450[2]	708	119	20.0	4.4	6.2	539	25.4	15.9	12.5	10.9	7.25	3.11
480	739	120	20.0	4.4	5.9	539	30.4	19.3	14.5	11.3	6.99	2.67
510	813	122	20.0	5.9	7.2	723	34.5	21.4	17.9	11.3	6.92	3.03
540	847	123	20.0	5.9	7.0	723	34.1	21.4	17.7	11.6	6.16	3.03
570	852	123	20.0	5.9	6.9	723	33.0	21.4	17.3	12.5	6.16	3.19
600[3]	850	124	14.1	4.1	4.8	506	22.1	13.9	11.7	12.9	5.63	3.16
630	858	126	16.6	4.9	5.7	600	21.7	13.0	12.1	13.0	6.05	2.88
660[4]	887	127	14.8	4.4	4.9	534	22.7	14.1	12.2	11.9	5.85	2.61
690	924	126	19.5	5.8	6.2	705	26.1	16.6	14.6	11.4	5.00	2.82
720	973	129	20.0	5.9	6.1	723	28.5	18.1	15.5	10.6	5.73	2.78
750[4]	1031	129	22.3	6.6	6.4	808	27.7	17.1	15.8	10.8	5.68	2.77
780	1070	129	30.7	9.0	8.4	1107	25.8	14.1	16.7	11.0	5.86	2.53
810	1103	130	30.0	8.9	8.0	1084	26.2	14.0	16.6	11.6	6.94	2.26
840	1150	131	32.2	9.5	8.2	1161	24.2	13.1	16.4	11.1	6.65	2.45
870	1186	132	35.0	10.9	9.1	1329	27.3	13.5	21.0	11.6	6.63	3.00
900	1208	133	35.0	10.9	9.0	1329	28.2	13.5	21.3	10.8	6.87	2.76
930	1233	133	38.7	12.0	9.7	1467	26.7	13.3	21.9	10.4	6.16	3.14
960	1251	133	45.0	14.0	11.1	1709	26.9	13.1	23.8	10.9	6.56	3.49
990	1254	132	40.6	12.6	10.0	1547	24.7	11.8	21.7	10.6	6.07	2.71
1020[5]	1187	132	41.8	13.0	10.9	1587	24.8	12.1	21.8	10.5	5.72	2.63
1050	1044	133	32.9	10.2	9.8	1250	33.8	19.2	23.1	9.8	4.45	3.06
1080	1090	133	40.7	12.6	11.6	1546	67.0	41.5	38.6	10.9	4.99	2.57
1110	1124	132	44.6	13.8	12.3	1695	76.1	47.4	43.6	11.0	5.13	2.76
1140	1149	...	45.0	14.0	12.1	1708	76.3	47.7	43.6	10.5	3.91	3.22

[1] Data from birth to 190 days of age appeared in Paper III, (3) this series.
[2] Bred at 467, 487 and 515 days of age.
[3] Aborted at 601 days of age.
[4] Bred at 662 and 765 days of age.
[5] Calved at 1032 days of age.

liminary results indicate that the milk produced by C–167 contained considerably less than 2.7 U. S. P. vitamin D units per quart. The blood plasma data fail to reveal any significant variations from normal. However, there were two gradual drops in the inorganic phosphorus values. The first drop was associated with the natural physiological disturbance due to abortion and the second was due to parturition.

Calf C–168. This calf received from 15 to 20 pounds of corn silage per day as the sole source of vitamin D from 269 days of age until the end of the experiment. The calf was suffering from severe rickets when first placed on experiment and the blood calcium and inorganic phosphorus values were 7.6 and 9.84 mg. per 100 cc. of plasma, respectively. The silage was readily consumed from the beginning and at 303 days of age the calf was able to rise to its feet with much less difficulty than a week earlier. The plasma calcium and inorganic phosphorus values were 9.3 and 5.48 mg. at 303 days of age and by the following week they had returned to normal, 10.9 and 6.76 mg., respectively. The gains in body weight were also greater from this time on until the animal was cured of rickets and slaughtered at 371 days of age. The terminal calcium and inorganic phosphorus values were 11.9 and 7.27 mg. The kidneys showed extensive areas of scar tissue.

Calf C–169. This calf received 15 pounds of corn silage per day as the sole source of vitamin D beginning at 348 days of age. It was severely rachitic and had difficulty in rising to its feet. The blood calcium and inorganic phosphorus values were 8.0 and 5.84 mg. per 100 cc. of plasma. The corn silage was readily consumed and 10 days later the calf was able to rise to its feet with much less difficulty. The blood values were approaching their normal concentrations by 370 days of age and the calf began to gain in body weight. C–169 was cured from rickets when slaughtered at 414 days of age and the terminal calcium and inorganic phosphorus values were 12.3 and 6.79 mg. The kidneys showed more extensive areas of scar tissue than observed in C–168. The data are tabulated in Table 6.

Calf C–188. This calf was 428 days of age and had been suffering from rickets for more than 200 days when corn silage was added to the ration as the sole source of vitamin D. The animal was severely rachitic at this time and was only maintaining a constant body weight. The blood calcium and inorganic phosphorus values were 7.2 and 7.06 mg. per 100 cc. of plasma. The silage was readily eaten but the grain was refused part of the time. By 472 days of age the animal was extremely stiff and lame and was rarely seen standing so that it became necessary to place the feed in a basket on the floor of the stall. The plasma calcium had now increased to 7.8 mg. but the inorganic phosphorus had declined to 4.51 mg. Placing the feed before the animal resulted in an increase in silage consumption but no improvement was noticed in its well-being. At 504 days of age the animal was observed

TABLE 6

C–169. Growth data, mineral and silage intakes and blood plasma values

AGE	WT.	HT.	DAILY SILAGE INTAKE				AV. DAILY INTAKE			BLOOD PLASMA		
			Silage	D.M.	D.M. per kilo	Vit. D units	Ca	P	Mg	Ca	P	Mg
days	*lb.*	*cm.*	*lb.*	*lb.*	*gm.*	*U.S.P.*	*gm.*	*gm.*	*gm.*	*mg. per 100 cc.*		
340[1]	364	98					15.7	10.9	6.3	8.0	5.84	2.62
347[2]	360						16.6	11.6	5.6			
350	360		6.7	1.5	4.1	180	18.2	12.1	8.1	9.6	4.22	3.31
360	367		14.5	3.2	8.7	391	18.9	11.8	9.3	10.6	4.70	2.28
370	377		15.0	3.3	8.7	404	19.2	11.9	9.5	10.5	5.25	3.43
380	372	103	15.0	3.3	8.9	404	19.2	11.9	9.5	11.0	5.65	2.90
390	387		15.0	3.3	8.5	404	19.2	11.9	9.5			
400	402		15.0	3.3	8.2	404	19.2	11.9	9.5	11.6	6.25	3.02
410	421	105	15.0	3.3	7.8	404	19.4	11.9	9.5		6.07	
414[3]	447		15.0	3.3	7.4	404	19.4	11.9	9.6	12.3	6.79	2.45

[1] Convulsion at 344 days of age.

[2] Started on silage at 348 days of age.

[3] Slaughtered.

struggling to its feet, breathing hard and with nostrils distended. The following week C–188 was emaciated, unable to rise to its feet and refused all feed and water. The plasma calcium and inorganic phosphorus values at this time had declined to 7.1 and 2.44 mg. The animal lapsed into a comatose condition at 518 days of age and failed to respond appreciably either to intravenous injections of solutions of calcium gluconate, glucose and magnesium sulfate or to a subcutaneous injection of viosterol. Death occurred at 520 days of age. There were patches of scar tissue in the kidneys, the muscle tissue showed considerable edema and there were evidences of muscle injury around the leg joints. The most characteristic autopsy finding was the generalized condition of pitting and erosion of the articular surfaces of the long bones. Illustrations and a detailed description of the histological findings are given elsewhere (11).

Calf C–195. This calf was 366 days of age and had suffered from rickets for more than 60 days when corn silage was added to the rachitogenic ration as the sole source of vitamin D. The animal's legs were stiff and the knees were bowed markedly. The plasma calcium and inorganic phosphorus values were 9.5 and 3.01 mg. per 100 cc. at this time. The appetite for silage was only fair but it gradually improved and by the following month the calf was able to rise to its feet with much less effort. The addition of silage had little effect upon the blood constituents during the first two months but during the next two months, the concentration of calcium returned to normal and the inorganic phosphorus manifested a slow but steady rise. Estrus was first noted at 413 days of age, at which time the bowing of the knees had become less marked. Improvement was rapid after that time. C–195 had recovered from rickets by 543 days of age, was bred and thereafter made normal gains in body weight. The heifer gave birth to a normal 82-pound bull calf at 813 days of age. The data secured from this animal are summarized in Table 7.

DISCUSSION

When calves less than 190 days of age were used as test animals it was impossible to either cure or prevent rickets by supplementing the basal rachitogenic ration with corn silage. A larger percentage of the calves survived until 190 days of age, however, when silage supplemented the basal ration (Table 3). This suggested that silage exerted some antirachitic activity although the amount ingested was insufficient to maintain or to restore health. Higher intakes of silage were precluded by anorexia. Calf C–145 had the best appetite for silage but the average consumption was less than six pounds per day. This amount of silage was equivalent to a daily intake of approximately 5 grams of silage dry-matter per kilo of body weight and was ineffective in curing rickets. The ingestion of three pounds of corn silage per day failed to prevent rickets in young calves.

TABLE 7

C–195. Growth data, mineral and silage intakes and blood plasma values

AGE	WT.	HT.	DAILY SILAGE INTAKE				AV. DAILY INTAKE			BLOOD PLASMA		
			Silage	D.M.	D.M. per kilo	Vit. D units	Ca	P	Mg	Ca	P	Mg
days	*lb.*	*cm.*	*lb.*	*lb.*	*gm.*	*U.S.P.*	*gm.*	*gm.*	*gm.*	*mg. per 100 cc.*		
240	471	110								12.0	6.45	2.68
270	514	112					19.2	13.2	7.6	10.0	7.30	3.15
300	527	115					19.5	13.2	7.8	10.3	5.74	2.53
330	536	116					18.8	13.2	7.5	9.7	4.98	2.52
360	545	117					18.5	13.2	7.4	10.1	4.37	2.60
365[1]	549	.....					18.5	13.2	7.4	9.5	3.01	2.50
390	547	118	16.1	4.3	7.9	532	25.2	16.6	13.5	9.7	2.49	2.43
420[2]	532	120	18.5	5.5	10.2	669	24.8	16.1	13.9	9.8	2.99	2.28
450	560	121	17.8	5.3	9.4	643	24.7	15.9	13.7	10.3	3.54	2.35
480	577	122	15.7	4.6	8.0	567	25.1	16.0	13.3	11.1	5.61	2.15
510	620	125	19.5	5.8	9.3	705	25.1	15.6	14.1	10.9	5.56	2.09
540[3]	655	125	23.8	7.4	11.2	903	26.2	15.2	17.4	11.6	5.63	2.50
570	670	123	19.5	6.1	9.0	741	23.8	14.9	16.2	11.6	5.98	2.35
600	705	126	24.2	7.5	10.6	919	26.8	18.0	19.1	11.7	6.03	2.98
630	724	127	24.8	7.7	10.6	941	26.7	15.5	17.9	11.4	5.78	2.89
660	770	126	25.9	7.0	9.1	857	26.1	14.8	17.0	11.8	6.00	2.55
690	823	126	27.2	8.4	10.2	1034	27.4	16.2	18.9	11.3	6.78	2.57
720	842	127	28.9	9.0	10.6	1099	28.0	16.4	19.7	11.7	6.83	2.87
750	873	127	27.2	8.4	9.6	1034	28.6	16.2	19.3	11.0	6.39	2.77
780	911		26.9	8.3	9.1	1020	27.3	16.6	18.8	11.5	5.93	2.59
810	921		25.5	7.9	8.6	971	26.8	15.7	18.2	10.6	5.56	2.62
813[4]										10.0	4.19	2.58

[1] Started on silage at 366 days of age.
[2] Estrus noted at 413, 457, 520 and 543 days of age.
[3] Bred at 543 days of age.
[4] Calved at 813 days of age.

When older calves were used, the clinical manifestations of rickets were alleviated in three out of four cases by the daily ingestion of 15 to 20 pounds of silage (Tables 6–7). Rickets was also prevented in C–167 from six months to three years of age by the ingestion of corn silage (Table 5). The abortion of C–167 was probably not associated with a vitamin D deficiency in view of the results reported by Moore and associates (12). The decrease in the concentration of inorganic phosphorus in the plasma of C–167 and C–195 at the time of parturition and the abortion of C–167 was associated with the physiologic disturbances caused by these acts rather than by a deficiency of the antirachitic factor. It has been shown (9) that such a change in the composition of the blood plasma is not uncommon in dairy cattle at the time of parturition.

In order to compare the results obtained with the various animals it seems convenient to express the intake of corn silage in terms of grams of silage dry-matter per kilo of body weight. On this basis, 7 to 10 gm. of silage dry-matter per day was not only effective in curing and preventing rickets but also supplied a sufficient amount of the antirachitic factor for normal growth and reproduction.

Calf C–188 ingested from 15 to 20 pounds of silage per day which was equivalent to 8 to 12 gm. of silage dry-matter per kilo of body weight, yet failed to recover from rickets. This was the only one of the older calves which failed to respond favorably to silage feeding. This calf is regarded as an atypical case. The inability to cure C–188 is ascribed to the severity of the rachitic condition which had developed before curative measures were begun. Failure to utilize its feed properly, together with its emaciated appearance and autopsy findings in the joints, indicate that the animal was suffering from far-advanced rickets which had given rise to other nutritional disturbances refractory to ordinary vitamin D therapy. Hutyra and Marek (13) state that if rickets is far advanced and has given rise to emphatic nutritional disturbances, death always follows, either through exhaustion or through some complication. The ultimate healing of the process is frequently prevented by ulcers formed in the course of the disease in the articular cartilages.

Bioassays made with rats indicated that 7.5 to 10.0 gm. of dry corn silage contained an equivalent of 2.7 U. S. P. units of vitamin D (Table 1). Assuming that 10.0 gm. of dry silage contained 2.7 U. S. P. rat units, during the period 1931–1934 inclusive, the daily intake of vitamin D units was calculated for each of the experimental calves (Tables 4–7).

The representative tables included in this paper show that the addition of corn silage to the rachitogenic ration appreciably increased the intake of magnesium. In view of the results of a recent investigation (2), it is possible that the presence of magnesium in silage may augment the efficacy of the antirachitic material in corn silage.

SUMMARY AND CONCLUSIONS

1. It was the purpose of this investigation to determine the antirachitic value of corn silage for dairy calves by the use of both curative and preventive feeding trials.

2. Samples of corn silage for the years 1931–1934 contained from 122 to 165 U. S. P. vitamin D units per pound of dry matter.

3. Calves less than 190 days of age were unsuitable test animals for both curative and preventive trials because of anorexia and failure to ingest adequate amounts of silage. In one instance, the feeding of corn silage to a yearling calf failed to cure severe rickets complicated with muscle atrophy and erosion of the articular surfaces.

4. The daily ingestion of an equivalent of 7.0 to 10.0 gm. of dry corn silage per kilo of body weight was effective in curing and preventing rickets in yearling calves and also supplied sufficient antirachitic material for normal growth and reproduction in dairy cows.

5. When corn is cut at the usual stage of maturity for corn silage it possesses definite antirachitic qualities when fed to dairy cows.

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THE INFLUENCE OF STORAGE, PASTEURIZATION, AND CONTAMINATION WITH METALS ON THE STABILITY OF VITAMIN C IN MILK

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In 1921 Hess (1) stated that " . . . it requires a minimum of about 16 ounces of cow's milk to protect an infant from scurvy or to cure it." Today, however, milk is almost entirely ignored as a source of vitamin C. This is probably due to the fact that a majority of the early studies indicated that milk was an uncertain source of the antiscorbutic factor. On the other hand, the fact should not be overlooked that before the discovery of vitamin C, milk was the only important source of this vitamin for infants. More recently Schwartze, Murphy and Hahn (2) state " . . . we would estimate that 200 cc. daily of our raw milk less than 12 hours old would probably suffice to protect an infant from scurvy."

Recently, while studying the influence of the cow's ration on the vitamin C content of milk, the authors were impressed with the appreciable amounts of this vitamin found in the samples tested (3). In 197 samples of fresh milk from individual cows the vitamin C content ranged from 17 to 37 milligrams per liter, averaging about 26.

While the vitamin C requirement of either adults or infants is not definitely known, 27 milligrams per day has been suggested as an adequate amount for an adult (4). Fresh milk, therefore, may be an important source of vitamin C. This vitamin C must be preserved until the milk is consumed if market milk is to be recognized as a reliable source.

Soon after the discovery of vitamin C, it was found that quick boiling of milk destroyed less of the vitamin than pasteurization at 143° F. for 30 minutes (5), and that contamination of the milk with copper greatly increased the loss (6). These findings were confirmed in later studies and some important differences were demonstrated with certain types of commercial pasteurizers (7, 8, 9, 10). It has not been determined whether the lower vitamin C content usually found in pasteurized milk is due to loss during the process of pasteurization, or to an increased rate of progressive loss after this treatment, or whether both may be contributing factors.

It is known that, during pasteurization, milk may be somewhat contaminated with the metals of which the pasteurizer is made (11, 12). The effect

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of contact with milk pail and storage can, and the effects of contact with metal and air in the process of cooling and straining are less certain. The relation of such slight contamination to either immediate loss of vitamin C or to increased progressive loss is unknown.

The present study was undertaken to determine more clearly the relative effect of several factors on the vitamin C in milk. The loss during storage of both raw and pasteurized milk was first studied. Loss during the process of pasteurization, and after contamination with metals either by direct addition to the milk, or by addition to the ration, was also studied.

I. INFLUENCE OF STORAGE AND PASTEURIZATION

Procedure

To obtain milk as free as possible from any kind of contamination, samples were taken directly from aluminum milk pails at the college dairy barn and cooled in glass bottles. Parts of some of these samples were pasteurized in 50 ml. pyrex glass flasks. Samples of milk were also obtained at several milk plants using different types of commercial pasteurizers.[2] Since some of these plants were as far as 125 miles from the laboratory, approximately 9 hours elapsed between the collection and testing of samples from such plants.

Samples were taken just before pasteurization and again after the milk had been pasteurized, cooled and bottled. They were packed in ice, brought to the college laboratory, and tested after several intervals for vitamin C with 2–6-dichlorophenolindophenol (Bessey and King 13). The samples were stored at approximately 40° F. during the intervals between tests. The types of pasteurizers studied, the intervals after pasteurization at which the milk was tested, the Vitamin C content and the losses due to storage, to pasteurization, and to both pasteurization and storage are shown in table 1.

Results

In the study of table 1, first consideration should probably be given to the greater stability of vitamin C in fresh raw milk than in any of either the raw or pasteurized samples secured at commercial pasteurizers. Even the usual procedure of straining and cooling over a well-tinned, copper, tubular cooler produced an appreciate loss during storage.

No immediate loss resulted from pasteurization by the short time high temperature method (Types B and D). This agrees with the results of other workers where pasteurization involved similar temperatures and holding periods (8, 9, 10). The progressive loss due to storage also was

[2] The help of Mr. O. L. Pretz of Kansas City, Mr. L. Bauman of Lawrence, and Mr. J. B. Jarvis of Topeka in securing and collecting these samples is very much appreciated.

TABLE 1

Influence of storage and pasteurization on vitamin C in milk

	TYPE				SAMPLES			AVERAGE VALUES FOR VITAMIN C									
								Hours after sampling				Loss in per cent due to storage only, and to storage plus pasteurization. (Hours stored)					
					Number plants represented	No. samples	Raw *vs.* Past.	2	9	24	48	2–24		9–24		9–48	
								Vit. C in Mg./liters				Storage only	Past.+ Storage	Storage only	Past.+ Storage	Storage only	Past.+ Storage
	FRESH RAW MILK (not pasteurized)																
A	Direct from milk pail				1	1275	Raw	25.7				7					
	" " " "				1	89	Raw	25.0		23.3							
	Strained, and cooled over well tinned copper				1	68	Raw	21.6		15.4							
	LABORATORY FLASK PASTEURIZATION (Using raw milk aged 9 hours in type B and aged 3 hours in type C)																
	Pasteurizer used	Material	Temp. °F.	Holding time min.													
B	Conical flasks heated in water bath	Pyrex glass	160	1	1	13	Raw	21.0		19.9		5.2					
							Past.	21.3		20.7		2.8	1.4				
							% loss	−1.4		−4.0							
C	As in type B	Pyrex glass	143	30	1	8	Raw	20.5	17.5	12.5		39		29			
							Past.	15.8	13.3	10.2		35	50	23	42		
							% loss	23	24	18							

TABLE 1—(*Continued*)

	TYPE				SAMPLES			AVERAGE VALUES FOR VITAMIN C									
								Hours after sampling				Loss in per cent due to storage only, and to storage plus pasteurization. (Hours stored)					
					Number plants represented	No. samples	Raw *vs.* Past	2	9	24	48	2–24		9–24		9–48	
								Vit. C in Mg/liters				Storage only	Past + Storage	Storage only	Past + Storage	Storage only	Past + Storage
	Pasteurizer used	Material	Temp. ° F.	Holding time min.													
	COMMERCIAL PASTEURIZATION (Using mixed raw milk from night and morning, aged 17 hours and 5 hours respectively, when sampled)																
D	Internal tubular continuous flow (short time-high tem.)	Stainless steel	160	0.3	2	3	Raw		17.1	15.0	12.5			12		27	
							Past.		16.9	16.1	12.0			4.8	6	29	30
							% loss		1.7	−7.3	4.0						
E	Tubular preheater, glass lined holding vat	Tinned copper, glass	143	30	1	2	Raw		15.4	12.0	9.1			22		41	
							Past.		11.1	9.8	5.9			12	37	47	62
							% loss		28	18	35						
F	Spray vat	Stainless steel	143	30	4	11	Raw		16.4	14.4	12.1			12		26	
							Past.		10.8	7.6	4.8			30	54	55	71
							% loss		34	47	60						
G	Coil vat	Tinned copper	143	30	5	11	Raw	23.4	18.8	16.5	11.9	29		12		37	
							Past.	16.4	11.6	7.6	4.9	53	68	34	60	58	74
							% loss	29	38	54	59						
H	Internal tubular continuous flow (30 min.-holding	Tinned copper	143	30	2	5	Raw		13.4	11.1	8.7						
							Past.		6.0	3.3	2.7			17		35	
							% loss		55	70	69			45	75	55	80

[a] Precision of measurement is about 1 mg. per liter. Variations of less than about 5 per cent have doubtful significance.

very much less than with any other method of pasteurization studied. In fact, practically no loss resulted from storage for 24 hours after pasteurization. This was true for both the laboratory pasteurization in glass flasks (Type B) and for commercial flash pasteurization in stainless steel equipment (Type D).

It was to be expected that pasteurization by holding at 143° F. for 30 minutes would reduce the vitamin C either immediately or after storage of the pasteurized milk. An immediate loss was found even when the milk was pasteurized in glass flasks where there was very little agitation and very little contact with outside air (Type C). The raw milk used in Type C pasteurizers did not show as good storage stability of vitamin C as the milk used in Type B pasteurizers. It was more nearly comparable to the raw milk used in the commercial pasteurizers. The first observed loss after pasteurization in commercial types E and G was only slightly greater than the immediate loss under laboratory conditions.

The loss of vitamin C on storage of pasteurized milk is shown in table 1 both as percentage of the first value after pasteurization, and also as percentage of the raw milk of equal age. By either comparison the progressive loss after type C pasteurization was no more than for the raw milk. Among all the commercial types using the 30 minute holding period, only the glass lined vat (Type E) produced pasteurized milk where loss of vitamin C on storage was as small as in the raw milk.

It was anticipated that the stainless steel spray vats (Type F) would be superior to the tinned copper coil vats (Type G) in conserving the vitamin C content of milk. The agitation of the milk was less vigorous in the spray vat and the stainless steel construction should minimize contamination with copper. The results indicated some superiority for type F compared to type G. That the difference was not as marked as was expected can be attributed to at least two possible factors. In the first place there was probably contamination of the milk with copper in equipment through which the milk was handled before and after pasteurization. This may account for the greater storage loss with type F than with type E. In the second place, as previously indicated, prolonged holding (143° F., for 30 min.) even without contact with any metal (Type C) resulted in serious loss of vitamin C.

In the commercial method using coil vats (Type G) it was possible to observe the rate of loss of vitamin C for the 2 to 24 hour storage period. The initial loss for these samples was not greatly different from the similar loss in samples similarly pasteurized in glass flasks (Type C). The progressive loss on storage was distinctly greater in type G than in types C or E, and slightly greater than in type F.

The internal tubular pasteurizers (Type H) should be as effective as the laboratory flasks (Type C) in avoiding contact of the hot milk with outside air. All the vat pasteurizers (Types E, F, G) permit much greater contact of the milk with outside air. On the other hand, the amount of metallic surface in contact with the milk and the velocity of the milk at this surface is greater in type H.

It was impossible to evaluate exactly the amount of exposed copper in various parts of the equipment in the two plants using type H pasteurizers, or to distribute the cause for the loss of vitamin C between the type of pasteurizer and the condition of the pasteurizer and accessory equipment. In one plant the vitamin C in the raw milk was improved by avoiding a poorly tinned cooler at the receiving vat. In the other plant the final cooler appeared to be the part containing most serious exposure of copper. When this cooler was used with a new short time high temperature pasteurizer, no serious loss of vitamin C was caused. In both plants the pasteurizers themselves appeared to be in fair condition. In these two plants both the initial loss and the progressive loss on storage were greater than for any other type of pasteurizer studied.

The results with laboratory type C and with commercial types E, F, G and H, indicate that the 30 minute holding process of pasteurization is not well adapted to the conservation of vitamin C in milk.

II. INFLUENCE OF CONTAMINATION WITH METALS

Procedure

The results just reported might suggest that contamination of milk with copper is indicated when the loss of vitamin C on storage after pasteurization is excessive. If addition of the metals contained in stainless steel should not increase the loss of vitamin C in milk, the unexpected loss in stainless steel vats could be assumed to be due to other causes.

The effect of added metals was studied by adding sulfates of several metals to the milk. Sulfates were used because they are readily soluble salts. The metals studied were copper, iron, nickel, and chromium. Although aluminum is corroded by milk, it was not included because it has repeatedly been found equal to glass in avoiding loss of vitamin C. Tin was not included because it is not readily corroded by milk and also because any solution in which it could be added must be very strongly acid.

The first tests were conducted with copper and iron solutions because these metals are known to catalyze the oxidation of vitamin C. The first object was to obtain an estimate of the minimum concentration of added metal needed to produce a detectable effect on the vitamin C in the milk. Preliminary tests with copper and iron were followed by a series of 8 tests using about the minimum detectable addition of metal. In each test the

sample of milk was divided into four parts. One was used as a standard or check and one of the metals was added to each of the other three parts. Copper in the concentration of 5 p.p.b. was used in each of these 8 tests. Ten p.p.b. of copper and 100 p.p.b. of iron were also used in 4 of the tests while in the other 4 tests these were replaced by 1000 p.p.b. of chromium and 1000 p.p.b. of nickel.

The amounts and kinds of metal added, the times at which vitamin C was tested, and the amounts found, are shown in tables 2, 3, and 4.

TABLE 2

Vitamin C in milk to which copper was added as sulfate[a]

ADDED COPPER[b] P.P.M.	RAW VS. PAST.	PER CENT OF INITIAL CONTENT	PER CENT LOSS 2–24 HRS. STORAGE	HOURS AFTER PASTEURIZING			
				2	9	24	48
				Vit. C in mg./liter			
0	R	100	23	23.4	21.5	17.9	11.1
	P	84	18	19.7	17.9	16.0	11.1
			% loss	16	17	11	0
0.1	R	92	45	21.5	18.5	11.7	6.2
	P	68	54	16.0	13.5	7.4	2.5
			% loss	25	27	37	75
0.3	R	80	79	18.5	13.5	3.1	3.7
	P	39	73	9.2	4.9	2.5	1.8
			% loss	50	64	19	51
0.6	R	68	84	16.0	7.4	2.5	2.5
	P	13	42	3.1	1.8	1.8	1.8
			% loss	80	76	28	28

[a] These samples were prepared from a single composite of morning's milk taken from a can at the college creamery about 7: 30 a.m. The copper was added about 8: 00 a.m. The pasteurization at 143° F. for 30 min. in glass flasks was completed about 9: 00 a.m.

[b] Addition to another sample of milk of 20 times the maximum amount of the water used in making these solutions caused no loss of vitamin C.

TABLE 3

Vitamin C in milk to which ferrous sulfate was added

ADDED IRON P.P.M.	PER CENT LOSS ON STORAGE				HOURS AFTER PASTEURIZATION					
	2–7 hrs.		7–24 hrs.		2		7		24	
					Vit. C in mg. per liter					
	raw	past.	raw	past.	raw	past.	raw	past.	raw	past.
0	16	13	46	54	19.2	17.6	16.1	15.3	8.7	7.0
1.0	18	17	36	45	15.2	14.0	13.1	11.7	8.4	6.4
			% loss		21	21	19	23	6	9

TABLE 4

Vitamin C in pasteurized milk to which various metals were added

METAL ADDED P.P.B.	AVERAGE		TEST NUMBER							
	Extra loss[a]	Mg./l	1	2	3	4	5	6	7	8
			Vit. C 24 hrs. after past. (mg./l)							
0	0	10.3	12.9	12.9	11.1	6.8	7.5	8.0	11.4	11.4
5 copper	28	7.4	7.4	8.0	8.0	3.7	6.1	6.1	10.1	10.1
10 "	60	4.2	3.1	3.7	6.8	3.1				
100 iron	8	10.1	12.3	12.3	9.9	6.1				
1000 nickel	19	7.9					4.7	6.1	10.1	10.8
1000 chromium	11	8.6					5.7	6.7	10.8	11.4

[a] The losses were calculated as average percentages of the individual mg./l of vitamin C in the samples to which no metal was added. Losses of less than 20 per cent have doubtful significance.

Results

It is evident from table 2 that addition of copper produced an extra progressive loss of vitamin C in both raw and pasteurized milk. Copper did not produce a serious immediate loss in the raw milk. This finding is based on the estimated initial vitamin C contents obtained by extrapolating the values in table 2 to the time the copper was added. The losses 2 hours after pasteurization or 3 hours after addition of copper are small relative to the losses on longer storage and indicate the same finding. There probably was an immediate loss on pasteurization after the addition of 0.1 or more p.p.m. of copper. The data are, however, inadequate to distinguish accurately between an immediate loss and a progressive loss whose rate slowed as the vitamin content of the milk diminished. When only 5 p.p.b. of copper were used, the extra loss of vitamin C was evident only after pasteurization and storage for 24 hours.

The tests in table 4 indicate that 5 p.p.b. of copper added to milk produced a decrease of vitamin C in the pasteurized stored milk. This result is confirmed by comparison with the progressively shorter intervals needed to detect the influence of the larger amounts of added copper.

In table 3 the loss due to 1.0 p.p.m. added iron appears to be somewhat more than the minimum significant loss. It is also noteworthy that the extra loss was as evident 2 hours after addition of iron as at any other time and was about equally evident in the raw and the pasteurized milk.

When 100 p.p.b. of iron was added (Table 4), the observed loss of 8% although rather consistent, was hardly more than the experimental error.

Addition of 1.0 p.p.m. of chromium did not produce a significant loss of vitamin C either in the stored pasteurized milk as shown in table 4 or in the raw milk. Tests at intervals of 2 hours and 9 hours after pasteurization did not show greater effects.

The effects of 1.0 p.p.m. added nickel were more pronounced in the pasteurized than in the raw milk. The average effect was as great after 2 hours' storage as after 24 hours' storage. The average effect at both ages appeared to be more than the error of measurement but the effect in different samples of milk varied greatly.

It may be estimated conservatively that compared to copper, at least 20 times as much iron or 200 times as much chromium or nickel are required to produce comparable destruction of vitamin C. The significance of these ratios in choosing materials for pasteurizing equipment is further emphasized by the fact that copper or brass is probably 100 fold more soluble in milk than stainless steel (12). Of the four metals studied copper was the only one for which both pasteurization and storage increased the destructive effect of vitamin C in milk. This fact further substantiates the earlier inference that excessive loss of vitamin C after pasteurization and storage indicates contamination with copper.

III. INFLUENCE OF ADDED COPPER IN THE RATION

Procedure

Although Elvehjem, Steenbock and Hart (14) reported that addition of copper to the ration produced no significant increase of copper in the milk, it seemed worth while to test the effect of the added copper in the ration on the rate of loss of vitamin C in pasteurized milk. Accordingly eight cows were each fed 0.3 gram of copper as copper sulfate solution sprinkled on the ration each evening for four days. Samples of milk from each of these cows and from eight other cows giving milk of approximately equal vitamin C content were collected for 3 milkings following the first copper supplement and again after the fourth supplemental feeding.

Each sample of milk was divided into two parts, one of which was pasteurized at 160° F. for 1 minute. Both parts were analyzed after 2 hours and 24 hours storage at 80° F.

Results

The copper supplement did not at any time produce a detectable difference in the vitamin C content of fresh raw milk or of freshly pasteurized milk. The loss after pasteurizing and storing averaged 30 per cent for the control milk and 49 per cent for the milk produced on the copper supplemented ration. The difference of 19 per cent $\pm$ a standard error of 5.6 per cent indicates a critical ratio of 3.4. In other words, there is less

than 1 chance in 1000 that there is not a real difference between the two groups. The loss is the same order of magnitude as that produced by 5 p.p.b. of copper to the milk. The simplest interpretation of this result is that the increased copper in the ration did slightly increase the amount of copper in the milk.

The amount of added copper in milk needed to produce this effect on vitamin C stability is less than could be detected by chemical methods (11, 14). The deduction, that copper added to the ration produced additional copper in the milk, extends rather than conflicts with the test made by Elvehjem, Steenbock, and Hart. The large increase of copper in the ration needed to produce a barely detectable decrease of vitamin C stability in the milk indicates that normal variations of copper in the ration probably would not produce any significant effect on the vitamin C content of milk.

CONCLUSIONS

Milk, either raw or pasteurized by the short time, high temperature process, but uncontaminated with copper was held 35 hours without serious loss of vitamin C. Such milk may be an important source of vitamin C in human nutrition.

Stainless steel tubular short time high temperature pasteurizers were found to be well suited to the preservation of vitamin C in milk. There was no significant destruction of vitamin C during the pasteurizing process, and very little loss when the milk had been stored 24 hours after pasteurization.

The 30 minute holding process of pasteurization as investigated in five different types of pasteurizers was found not to be well adapted to the preservation of vitamin C in milk. Excessive losses were found even when contamination with copper was reduced to a minimum. The losses were frequently serious during the storage period after pasteurization as well as during the pasteurizing process.

Pasteurized milk to which 5 p.p.b. of copper had been added contained less vitamin C 24 hours after pasteurization than check samples without added copper. The addition of 0.1 p.p.m. of iron or 1.0 p.p.m. of either chromium or nickel to the milk produced less effect than 5 p.p.b. of copper. Only in the case of copper did both pasteurization and storage increase the destructive effect of the added metal.

Addition of 0.3 gram of copper daily to the ration produced a significant decrease in the stability of vitamin C in pasteurized milk and probably produced a corresponding increase in the copper content of the milk. Normal variations of copper in the ration would probably not produce any significant effect on the vitamin C content of milk.

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SOME EFFECTS OF THE PROPOSED NEW BACTERIOLOGICAL TECHNIQUES

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In 1910 the A. P. H. A. issued its first pamphlet on "Standard Methods of Milk Analysis." This has been amplified several times, and in 1935 the sixth, or latest edition was published. For some years there has been scattered agitation so to change the standard agar as to give larger colonies and higher counts. Sherman (1), in 1916, and Supplee, Whiting and Downs (2) in 1921 reported improvements by changing the medium. Later, in 1935, Bowers and Hucker (3) after studying several media, reported that the best growth was to be had by using a tryptone glucose skimmilk agar. Pederson and Yale (13) reported to the A. P. H. A. in 1933 their work with 32° C. incubation, wherein they got approximately a 50 per cent increase in count over standard 37° C. temperature.

There has been considerable opposition to proposed changes in agar and incubation temperatures, as evidenced by the report of R. S. Breed (4), who called attention to the necessity of cooling systems in case 30° C. incubators were to be used. J. F. Norton (5) in 1928 reported that higher counts were of minor importance in milk control, rather uniformity was needed. A. H. Robertson (6) in 1921 stated that higher counts on agar plates would not be more uniformly proportionate to the total number present. George E. Bolling (7) in 1932 regretted the suggestion of obtaining higher plate counts, remarking that their incorporation into Health Department records would upset comparisons and shake the confidence of the public in the purity of milk supplies. H. W. Conn (8) in 1915 and Breed and Stocking (9) in 1920 asserted that exact composition of the media and the necessity for absolutely exact counts were overemphasized.

In the report of Bowers and Hucker (3) they state the higher counts on the proposed new agar would not seriously affect producers of high grade milk. However, in the same paper they state the problem of whether it is practical to use the tryptone glucose skimmilk agar for routine counts, as they might affect present standards and work a hardship on producers and dealers unless standards are changed. Now, of course, comes the consideration as to whether or not it would be possible to change Federal, State and Municipal standards of bacteria counts all over the area covered by the A. P. H. A. if any change in media were made. Again in the same bulletin Bowers and Hucker state: "The adoption of this type of agar (tryptone

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glucose skimmilk agar) which would materially increase the counts secured from milk samples also involves certain other practical considerations in the relation of the counts obtained to the standards fixed by present milk grading ordinances. It is evident that if a medium is adopted which increases the counts as obtained in routine milk grading laboratories, the standards fixed for milk grades should be modified, or otherwise producers and dealers will find their milk automatically degraded due to the increased counts found in laboratory analyses."

The composition of the proposed new agar is:

Tryptone	0.5%
Glucose	0.1%
Agar	1.5%
Skimmilk	0.5%
Distilled water	

The new proposed incubation temperature as recommended by Pederson & Yale (10) is 32° C. The question immediately suggests itself as to the ability of analysts to keep the temperature of the ordinary incubator down to 32° (89.6° F.) on hot days in many parts of the country.

EXPERIMENTAL

As these proposed changes are of tremendous importance to the dairy industry, an investigation along these lines concerning bacterial counts due to changes in media composition and incubation temperatures have been carried out by the writer. This investigation included the bacterial examinations of 1962 samples of different dairy products, and the statistical analysis of the results obtained, thereby obtaining comparisons between:

(a) 37° C. standard agar and 37° C. tryptone skimmilk agar.

(b) 37° C. standard agar and 32° C. standard agar.

(c) 37° C. standard agar and 32° C. tryptone skimmilk agar.

These plates were all made between the latter part of August and late December 1935, the low temperature portion having been performed during November and December. The plates used were placed in two types of incubator: (a) water jacketed Board of Health type, gas heated, and (b) transite board, electrically heated. These incubators were used on alternate days, so the whole series of samples represents a cross section. The samples to be designated: "Pasteurizzed in Laboratory" were in sterile tube vials, heated quickly to 143° F., placed into a thermostatically controlled water bath at 143° F., and held at this temperature for 32 minutes. The tubes were then plunged into ice-water and cooled immediately below 50° F. The "Washed bottles" were quart bottles taken from soaker-type bottle washers. Fifty cc. sterile water were used and one cc. plated. The "Washed cans 40

quart'' were taken from a circular-type jet washer. Four hundred cc. sterile water were used and one cc. plated. In the case of ice cream, one cc. rather than one gram, was plated. The samples were all plated in H. P. Hood & Sons Laboratory at Boston, but the samples represent dairy products from entire New England. The agar was all made in our laboratory from Difco products, the pH of the standard agar being approximately 6.7, no correction having been made because none was necessary. The plates were incubated for 48 hours, plus or minus three hours, and comparative plates were always placed in the same incubator and reasonably near by each other. The plates were all counted in the colony counting device of the author (11), giving magnification and illumination as called for in ''Standard Methods.'' All averages quoted are arithmetical.

TABLE 1

Increases in bacterial counts

37° C. standard agar vs. 37° C. tryptone agar. (941 samples)

SAMPLES	AVERAGE 37° C. STANDARD AGAR COUNTS	AVERAGE 37° C. TRYPTONE AGAR COUNTS	PERCENTAGE INCREASE OVER 37° C. STD. COUNTS	NUMBER OF SAMPLES
Grade A Producers' Cans—Raw	18,500	23,000	24	111
Grade A Pasteurized and Bottled	1,800	3,900	116	82
Grade B Tank Cars—Raw	90,800	171,000	88	111
Grade B Tank Cars—Pasteurized in Laboratory	3,140	7,200	129	111
Grade B Producers' Cans—Pasteurized in Laboratory	3,400	7,290	114	216
Grade B Pasteurized and Bottled	4,900	14,700	200	114
Certified Milk	1,150	1,380	20	33
Cream Shippers' Cans	112,000	265,000	114	103
Washed Bottles	2,410	7,250	200	30
Washed Cans, 40 Qt.	156,000	249,000	88	30

In Table 1 will be found the data from 941 samples during August and September and the incubation temperature was 37° C. in each case. The standard agar counts and the tryptone agar counts are presented as averages of all plates made of each particular type of product, such as Grade A producers cans raw, Grade A milk pasteurized and bottled, etc.

The third column of figures shows the percentages of increase obtained by the use of tryptone agar over the counts of plates made on standard agar from the same samples. It will be seen readily that the better grade products show the smallest percentage increase, for example, Certified milk of little over 1000 bacteria per cc. shows only a 20 per cent increase due to tryptone agar, and Grade A producers' milk 24 per cent increase. On the

TABLE 2

Increases in bacterial counts

37° C. standard agar vs. 32° C. standard and 32° C. tryptone agar. (1021 samples)

SAMPLES	AVERAGE 37° C. STANDARD AGAR COUNTS	AVERAGE 32° C. STANDARD AGAR COUNTS	PERCENTAGE INCREASE OVER 37° C. STD. COUNTS	AVERAGE 32° C. TRYPTONE AGAR COUNTS	PERCENTAGE INCREASE OVER 37° C. STD. COUNTS	NUMBER OF SAMPLES
Grade A Producers' Cans—Raw	7,200	12,100	68	14,500	101	109
Grade A Tank Cars—Raw	11,900	25,000	110	35,440	197	88
Grade A Pasteurized and Bottled	1,123	2,960	163	4,360	288	123
Grade B Tank Cars—Raw	116,070	153,400	32	285,100	122	81
Grade B Tank Cars—Pasteurized in Laboratory	3,919	8,342	113	16,212	311	26
Grade B Producers' Cans—Pasteurized in Laboratory	2,680	6,700	150	8,200	206	112
Grade B Pasteurized and Bottled	4,202	8,800	109	24,225	476	119
Certified Milk	1,636	1,708	4	2,008	23	84
Cream Shippers' Cans	51,300	152,000	196	297,200	479	95
Cream Pasteurized and Bottled	52,800	352,400	558	385,500	630	123
Ice Cream	48,019	106,643	122	177,623	269	21

other hand, the Grade B bottled milk pasteurized gives a 200 per cent increase. Grade B milk shows a greater increase than does Grade A. The observation of Bowers & Hucker (3) that, "this is a good medium for growing bacteria in pasteurized milk" is certainly borne out in this table.

In Table 2 are the data obtained during October, November and December on 1021 samples of dairy products, comparing the 37° C. standard agar with both the 32° C. standard agar and the 32° C. tryptone agar. Here some very startling increases in bacteria count are evident. The first column of figures, 37° C. standard agar counts, show what might be called average bacteria counts in most cases, and with one or two exceptions the 32° C. standard agar count does not appear much higher than did the 37° C. tryptone count from the previous table. Cream pasteurized and bottled jumps rather alarmingly from 52,000 to 352,000 or an increase of 558 per cent, but Certified milk and Grade A milk, as in the previous table, are low.

With the combination of tryptone agar and 32° C. incubation tremendous increases result. The anchor, however, still seems to be Certified milk, which shows an increase of only 23 per cent, where all of the other types of product show serious percentage increases over 37° C. standard agar. Grade B milk shows a 476 per cent increase and bottled cream 630 per cent. Even Grade A milk bottled shows the startling increase of 288 per cent in this technique over the 37° C. standard agar. At this point it might be well to refer again to Bowers and Hucker (3) who state that the adoption of this agar would not materially affect dealers who handle really high grade pasteurized milk. Certainly increases in counts in Grade B milk of 200, 109 and 476 per cents are very serious bacterial increases and might materially affect dealers in those areas where bacteria counts are published.

TABLE 3

Percentage of cases where the 37° C. tryptone agar count exceeded the 37° C. standard agar count. (941 samples)

INCREASE IN COUNT	GRADE A PRODUCERS' CANS RAW	GRADE A PAST. AND BOTTLED	GRADE B PAST. AND BOTTLED	CREAM SHIPPERS' CANS PAST.	CERTIFIED MILK
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
Over 50	39	42	77	94	15
" 100	23	22	52	84	6
" 200	10	11	30	63	3
" 300	4	7	22	44	3
" 400	2	2	19	36	1
" 500	2	2	16	28	1
" 1,000	1	1	6	15	0
" 4,000	0	0	1	5	....
" 8,000	....	....	0	0	....

TABLE 4

Percentage of cases where the 32° C. standard agar count exceeded the 37° C. standard count. (1021 samples)

INCREASE IN COUNT	GRADE A PRODUCERS' CANS RAW	GRADE A TANK CARS RAW	GRADE A PAST. AND BOTTLED	GRADE B TANK CARS RAW	GRADE B PAST. AND BOTTLED	CREAM SHIPPERS' CANS PAST.	CREAM PAST. AND BOTTLED	CERTIFIED MILK	ICE CREAM
per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Over 50	45	58	69	40	58	73	96	21	66
" 100	19	45	53	26	39	53	91	12	43
" 200	6	27	38	8	20	20	79	9	14
" 300	3	22	26	3	12	13	78	7	9
" 400	1	18	18	1	9	6	70	3	9
" 500	0	12	13	0	6	6	63	2	9
" 1,000	.....	7	3	.....	2	6	48	1	4
" 4,000	.....	0	0.8	.....	0	0	20	0	0
" 8,000	.....	.....	0	.....	.....	.....	10	.....	.....
" 10,000	.....	.....	.....	.....	.....	.....	9	.....	.....
" 20,000	.....	.....	.....	.....	.....	.....	2	.....	.....
" 40,000	.....	.....	.....	.....	.....	.....	0.8	.....	.....
" 80,000	.....	.....	.....	.....	.....	.....	0.8	.....	.....
" 100,000	.....	.....	.....	.....	.....	.....	0	.....	.....

TABLE 5

Percentage of cases where the 32° C. tryptone agar count exceeded the 37° C. standard agar count. (1021 samples)

INCREASE IN COUNT	GRADE A PRODUCERS' CANS RAW	GRADE A TANK CARS RAW	GRADE A PAST. AND BOTTLED	GRADE B TANK CARS RAW	GRADE B PAST. AND BOTTLED	CREAM SHIPPERS' CANS PAST.	CREAM PAST. AND BOTTLED	CERTIFIED MILK	ICE CREAM
per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Over 50	68	68	84	84	87	92	99	40	90
" 100	37	55	74	64	79	84	95	24	32
" 200	19	34	53	26	65	68	87	13	29
" 300	9	24	42	12	55	54	84	9	29
" 400	4	19	32	8	46	49	79	7	24
" 500	2	18	24	5	37	40	77	6	24
" 1,000	1	6	10	1	19	17	48	1	19
" 4,000	0	0	1	0	2	3	22	0	5
" 8,000	.....	.....	1	.....	.....	0.7	10	.....	0
" 10,000	.....	.....	0	.....	.....	0	9	.....	.....
" 20,000	.....	.....	.....	.....	.....	0	1	.....	.....
" 40,000	.....	.....	.....	.....	.....	.....	1	.....	.....
" 80,000	.....	.....	.....	.....	.....	.....	0.9	.....	.....
" 100,000	.....	.....	.....	.....	.....	.....	0	.....	.....

In Table 3 the same picture is presented from a different angle. This has reference again to the 941 samples examined on the two types of agar at 37° C. and shows the percentage of the samples analyzed giving various increases in count over the 37° C. plates. Considering the "Certified" column first, it will be noted that an increase in count of over 50 per cent was obtained in only 15 per cent of the cases, and going down the column we find that 1 per cent of the cases had an increase of over 500 per cent. However, the second-last column shows that in 94 per cent of all the cream samples analyzed an increase in count of over 50 per cent was obtained, and a high percentage of samples persisted as we proceed down the next left-hand column as far as a 4,000 per cent increase which occurred in 5 per cent of the samples tested. A similar picture may be observed from the Grade B pasteurized data, and to a lesser extent from that of the Grade A pasteurized milk.

In Table 4 may be found the same kind of data, setting forth the 1021 samples plated with the 32° C. standard agar against the 37° C. standard agar. This picture is not unlike the previous one, except that in the case of cream a new column, "cream pasteurized and bottled" has been added. Now the increases are getting up into high figures, for in almost one per cent of the samples tested an increase in count of over 80,000 per cent was obtained. In one of these cases bottled cream gave 700 bacteria per cc. at 37° C. and 600,000 bacteria per cc. at 32° C. Some other tremendous differences obtained in the same way were: 3,800 vs. 480,000, 13,200 vs. 1,700,000, and 4,000 vs. 1,000,000.

Table 5 is again similar to the previous tables, showing the occurrence of increased counts in the case of the 32° C. tryptone plates as against the 37° C. standard plates. It is obvious that the percentages are higher in nearly every case, and sharply higher in many cases. Grade A producers' cans, for instance, show an increase of from 45 to 68 per cent, Grade B tank cans from 40 to 84 per cent, Cream cans from 73 to 92 per cent, and Certified Milk from 21 to 40 per cent. This demonstrates the combined effect of lower incubation temperature and tryptone agar.

SUMMARY

In Table 6 is shown the fact that in this work a considerable number of the samples tested were sufficiently higher in count with tryptone agar to bring them into the class of illegal milk in Massachusetts. The same also applies to 32° C. incubation. It is conceivable that should such increases in count actually occur as a result of the proposed new methods, serious losses in milk consumption might result due to lack of public confidence in the quality of dairy products.

TABLE 6

City of Boston average counts June 1 to Dec. 1, 1935, and their relationship to counts obtained under proposed new techniques

	MARKET MILK	GRADE A MILK
City of Boston counts—standard agar	11,600	3,300
Massachusetts state standard	40,000	10,000
Increase in city of Boston milk counts required to exceed state standard	245%	203%
Percentage of cases these increases occurred in this experiment:		
In 37° C. tryptone agar	26%	11%
In 32° C. standard agar	16%	38%
In 32° C. tryptone agar	60%	53%

It is important to observe that if these proposed methods be adopted, there is no assurance other methods for obtaining higher counts shall not be proposed at a later date. With such increases in counts as produced by changes in method, public and private bacteriological records might be confused for years.

It has been suggested that health departments might change their bacteriological standards to meet these proposed changes in technique. The writer is skeptical as to the probability of many health departments actually doing this, and if changes in standards were accomplished, it seems that these changes would lack uniformity.

Unless such proposed new methods can be shown without question to have a bearing on the health of the consumer, their adoption should proceed with the highest degree of caution.

CONCLUSIONS

1. Greater numbers of bacterial colonies may be demonstrated from samples of milk products by tryptone glucose skimmilk agar and 32° C. incubation than by the use of the present standard technique.

2. Using these changes in technique, the changes in count in some types of dairy products, as compared with the present standard method, have been tremendous—in certain instances variations of over 80,000 per cent having been noted.

3. Any change in existing standard methods should be adopted by the Committee on Standard Methods of Milk Analysis, only after the most extensive investigation concerning their adaptability by the entire industry.

4. Changes of this nature should be considered only if and when provision for proper bacterial standards for milk and milk products, based upon such new methods, have been developed, and if and when means have been

provided for regulatory agencies to make proportionate, uniform, and simultaneous changes in existing bacteria standards.

ACKNOWLEDGMENT

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CURD TENSION OF MILK AND ITS RELATIONSHIP TO FIRMNESS OF CURD IN CHEESEMAKING

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In experiments conducted in these laboratories on the manufacture of Swiss cheese it has been found desirable to measure the curd firmness of the kettle milk for the purpose of determining the effects of this and other related factors upon the quality of the cheese. Preliminary work has shown that when milk to be used in cheesemaking is selected on the basis of curd firmness, the use of soft-curd milk causes the cheese to have a relatively soft texture and to contain a high percentage of moisture, while the use of hard-curd milk causes the cheese to have a relatively firm and dry curd. The present work was conducted for the purpose of developing suitable tests for determining the curdling properties of milk to be used in the manufacture of cheese. In addition to the economic value of this work, an analysis of certain factors which cause variations in curd firmness is of particular scientific interest.

Allemann and Schmid (1) measured the rennet curd tension of milk and stated that the use of firm-curd milk markedly increased the firmness and decreased the whey-holding capacity of cheese curd, resulting in the curd-splitting or "glaesler" defect and causing the cheese to ripen slowly because of a deficiency of fermentable constituents for bacterial growth. They stated that the use of soft-curd milk caused the retention of a large amount of whey and the cheeses were soft and tended to flatten on the shelves; the curd was high in acidity, the ripening was abnormally rapid, and the eyes were overdeveloped, unclean, and irregular in shape. Price (9) and Hill and Merrill (6) found firm-curd milk more satisfactory than soft-curd milk for making Cheddar cheese.

The device used by Alleman and Schmid for measuring rennet curd tension was similar in principle to that used later in the Hill (5) curd test, although it differed somewhat in design. In the Hill curd test, which is the test commonly used by most workers in recent experiments, the coagulant used contains pepsin and calcium chloride; due to the addition of the latter reagent, the coagulated mixture contains approximately three times as much calcium as is contained in normal milk and the pH is reduced from about 6.6 to about 5.7. Largely because of the changes produced in the milk by this increase in the calcium content and the resulting change in hydrogen-ion concentration, some doubt has recently been expressed (7) (8) as to the

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validity of curd-tension data secured in tests in which the Hill reagent is used.

PROCEDURE

In the present work about 300 samples were tested, but although all data are included in the calculations, only the average figures are presented. The milk of each cow in a herd was tested twice, about 3 months intervening between each series of tests. The milk used, that produced by each cow in one day, was held at a temperature of 5° to 8° C. until tested, to eliminate the factor of significant bacterial growth after milking. The samples were tested within 4 or 5 hours after the morning milking.

The Hill curd test was carried out in the manner described by Hill (5). The percentage of casein was determined by the Walker (formol titration) method. All tests were made in duplicate, and no difficulty was encountered in obtaining satisfactory duplicate results.

In determining firmness of rennet curd, the procedure used in the manufacture of Swiss cheese was followed in every detail with the exception that the process was carried out on a small scale, 500 cc. of milk being used in each test. The temperature was 33° C. and the concentration of rennet extract in the milk was 0.018 per cent. The final firmness of the curd under these conditions was judged by manual examination during the cheese-making process and was scored on a scale of 10 to 130 (10, very soft; 130, very firm). The rennet coagulation time, under the above conditions, was also recorded.

A rapid and accurate procedure was developed for determining rennet coagulation time, as follows: 5 cc. of commercial rennet extract were made up to 250 cc. in water. The solution was mixed, warmed to 35°, and held at that temperature. Samples of milk containing 100 cc. were placed in 8-oz. bottles, the contents were warmed to 35°, and the bottles were placed in a water bath which was fitted with a 500-watt heater, a thermostat set to maintain the temperature at exactly 35°, and an air-driven stirrer. Five cc. of the rennet solution were added to each 100 cc. milk sample and the contents were mixed and allowed to syphon out through an inverted U-shaped capillary tube, dropping upon the inner surface of a tilted beaker. The time from the addition of rennet to the first appearance of a coagulation or flocculence was recorded as the coagulation time.

The rennet curd tension was determined at a temperature of 35° and with a rennet concentration of 0.018 per cent; the technique was the same as that used in the Hill curd test except that only rennet extract was used as the coagulant and the time allowed for the formation of curd was 45 minutes instead of 10 minutes. Five cc. of rennet extract were made up to 275 cc.

in water and 1 cc. of this solution was mixed with 100 cc. of milk. The measurements were made with the Curd-O-Meter (Hill curd tester).

In carrying out the alcohol test, 4 cc. of milk and 9 cc. of 78 per cent ethanol were mixed at 25° in a 15 cc. graduated centrifuge tube; the tubes were allowed to stand in a water bath at 35° for 30 minutes, and were then centrifuged for 10 minutes in a Babcock tester fitted with special centrifuge tube holders. The volume of precipitate in each tube, as read on the graduated scale on the tube, was recorded.

RESULTS

The data in Figure 1 show a striking lack of agreement between the Hill curd tension and the firmness of rennet curd. The minimum and maxi-

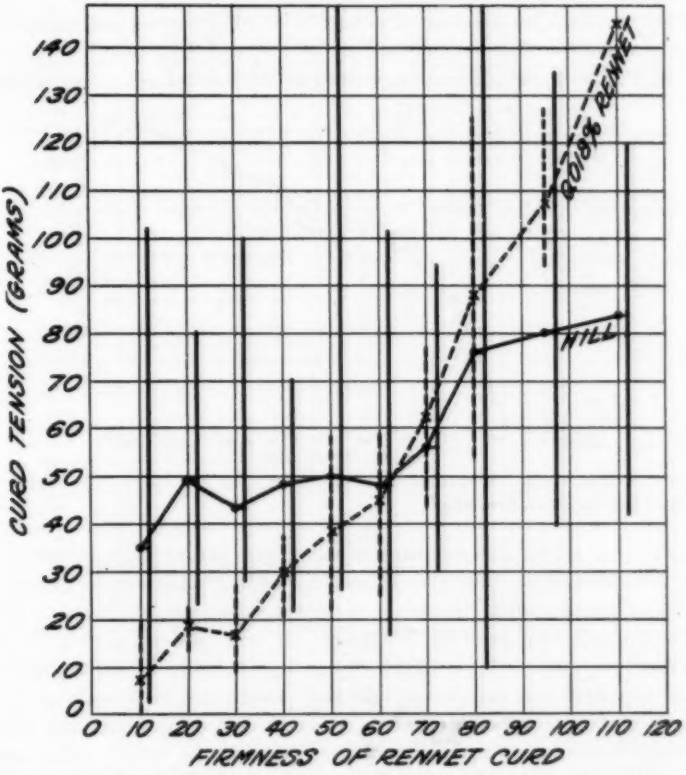

FIG. 1. Relationship between firmness of rennet curd and curd tension (points on curves indicate averages of values; vertical lines indicate ranges of values).

mum values, indicated by the heavy vertical lines, emphasize this lack of agreement. For example, a milk of which the numerical value for firmness of rennet curd is 10 may have a Hill curd tension varying between 3 and 102. The rennet curd tension, however, shows a comparatively much closer correlation to the firmness of rennet curd than does the Hill curd tension, not only from the standpoint of average values, but also in minimum and maximum values.

It was found that the rennet curd tension values of different milks vary over a wider range than do the Hill curd test values. In many instances milks which show large differences in rennet coagulability show only slight or negligible differences in Hill curd test values; moreover, some milks which would be classed as hard-curd milks by the Hill curd test are coagulated only very slowly by rennet.

When the data for firmness of rennet curd were plotted against data for rennet coagulation time, as determined by two different methods and indicated in Figure 2, satisfactory correlations were obtained. The minimum

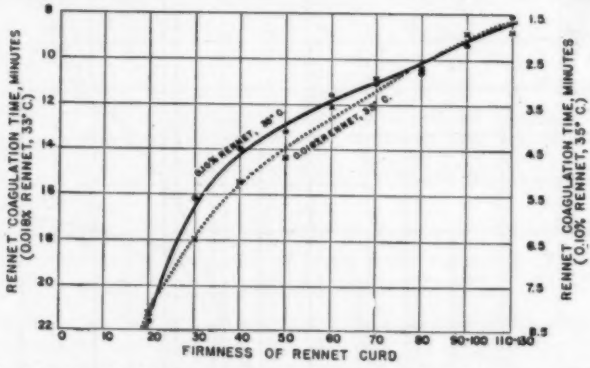

FIG. 2. Relationship between firmness of rennet curd and rennet coagulation time determined by two different methods.

and maximum values did not vary greatly from the average values, hence the rennet coagulation time may be used as a fairly satisfactory measure of firmness of rennet curd. However, as has been pointed out by Allemann and Schmid (1) and later by Bendixen (2), the two are not in all cases strictly proportional. The results indicate that, in milks in which the rennet curd is very firm, the coagulating efficiency of the larger amount of rennet (0.10 per cent) is relatively great, while in soft-curd milks the rate of curdling is more nearly proportional to the amount of rennet added, under the conditions shown. The coagulation time was in all cases abnormally long when the value for firmness of rennet curd was 20 or less.

The data in Figure 3 show that the rennet curd tension, measured in grams by means of the Curd-O-Meter, bears a definite relationship to the firmness of rennet curd in the cheese-making process.

There is a rather indefinite correlation between the rennet curd tension and the results of the alcohol test. The experimental data have shown con-

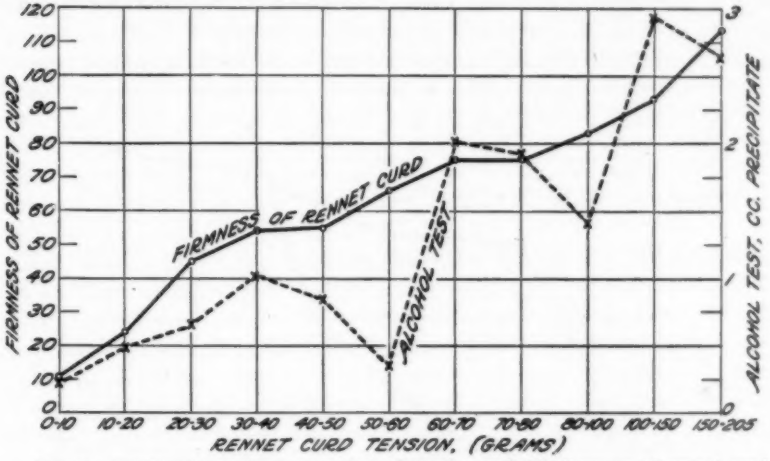

FIG. 3. Relationship between rennet curd tension and (1) firmness of rennet curd, and (2) alcohol test.

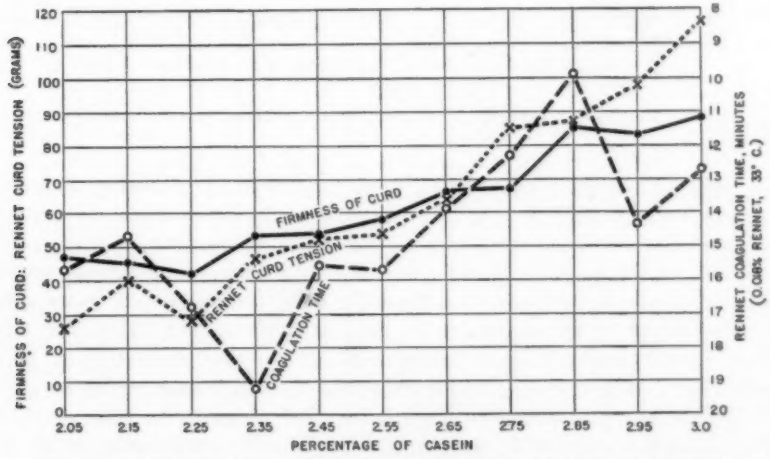

FIG. 4. Relationship between percentage of casein and (1) firmness of rennet curd, (2) rennet curd tension, and (3) rennet coagulation time.

clusively that most milks having relatively low rennet curd tensions are more stable to alcohol than those which produce firm rennet curds. Doan and Welch (4) found no consistent relationship between Hill curd tension and alcohol stability.

The percentage of casein was found to have a very indefinite relationship to the rennet coagulation time. It is shown in Figure 4 that the percentage of casein has a greater influence on the rennet curd tension and upon the firmness of rennet curd in the cheese process than upon the rennet coagulation time. An examination both of the averages of data, shown in

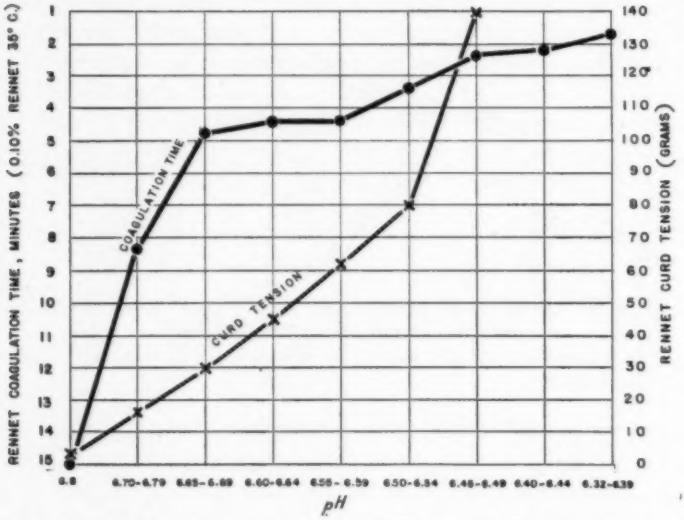

FIG. 5. Relationship between pH and (1) rennet coagulation time, and (2) rennet curd tension.

Figure 5, and of other data secured from tests on many individual samples of milk indicates that the pH is a major factor in determining the rennet coagulation time, while the percentage of casein is relatively more important as a factor in influencing the rennet curd tension. Correlations made on a large number of tests show that Hill curd test values are influenced to some extent by the original pH values of milk samples. However, the effect of pH is much more pronounced upon rennet curd tension and especially upon rennet coagulation time than upon Hill curd test values.

The influence of pH upon coagulation time seems to be most marked when the pH is above 6.65; the influence of pH upon curd tension seems to be most marked when the pH is below 6.50; the percentage of casein influences the curd tension at every point in the range of casein content.

Among 294 milk samples, the highest pH value was 7.45, the lowest 6.32, and the average 6.60. The weighted average pH, however, was slightly below 6.60, since the milks of many of the high-producing cows had relatively low pH values.

In addition to the results reported above, it was found that the rennet coagulation time was increased and the rennet curd tension decreased when milk was stored for from a few hours to three days at temperatures of 2° to 5°. Bendixen (2), working independently, showed that storage of milk to which an antiseptic has been added causes a decrease in the rennet coagulation of the milk, while Berry (3) and others (4) have shown that the Hill curd tension of milk is not changed by storage. Further experiments showed that stability to alcohol was increased when milk was stored and that alcohol stability, like rennet stability, was decreased by the addition of $CaCl_2$.

The effect of the homogenizing process in decreasing the Hill curd tension of whole milk has been shown by Theophilus and his coworkers (10) and by Doan and Welch (4). Bendixen (2) found that homogenization of skim milk caused no decrease in the firmness of rennet curd and no increase in rennet coagulation time, and Doan and Welch have shown that homogenization causes no decrease in the Hill curd tension of skim milk. The data shown in Table 1 indicate that homogenization of whole milk causes a marked softening of the rennet curd without changing the rennet coagulation time, and that homogenization of skim milk has no effect upon rennet curd tension or rennet coagulation time. These results indicate that the curd-softening effect of homogenization is probably due entirely to the

TABLE 1

Effect of skimming, pasteurizing, and homogenizing on the rennet curd tension and coagulation time of milk

SAMPLE NO.	1			2		
	Rennet curd tension	Rennet coagulation time		Rennet curd tension	Rennet coagulation time	
	g.	*min.*	*sec.*	*g.*	*min.*	*sec.*
Whole milk, untreated	39[1]	3	33	73[2]	2	20
Skimmed milk	56	3	58	91	2	28
Whole milk, pasteurized[3]	36	3	43	58	2	25
Whole milk, pasteurized and homogenized[4]	15	3	42	24	2	24
Skimmed milk, homogenized[4]				90	2	28

[1] Percentage of fat in milk, 4.3; [2] 2.8.

[3] Pasteurized at 62.5° C. for 30 minutes.

[4] Homogenized at 2,000 pounds pressure.

action of the process in causing an increase in the dispersion of the fat globules and thus hindering the subsequent aggregation of the casein micellae; Doan and Welch arrived at the same conclusion in work which differed from ours in that the Hill reagent was used as the coagulant. As further evidence in support of this assumption, it is shown in Table 1 that the rennet curd tension of whole milk is considerably lower than that of the same milk after separation, although the rennet coagulation time is not decreased by the removal of the fat.

The data in Table 1 also show the combined effect of homogenization and pasteurization in reducing the rennet curd tension of whole milk. The effect of homogenization is evidently much greater than that of pasteurization, although the latter process has an appreciable curd-softening effect, which, according to Bendixen (2), is proportional to the temperature used.

In studying relationships between mastitis and physical properties of milks, the following tests were used as evidences of mastitis: the presence of streptococci from the udder, strip cup test, pH, catalase test, and leucocyte count. The average data obtained in tests on 309 samples of milk are shown in Table 2. While the average rennet curd tension was relatively low and

TABLE 2

Effects of mastitis on properties of milk (average values)

		CASEIN[1]	pH	RENNET COAGULATION TIME		RENNET CURD TENSION	NUMBER OF TESTS
		%		*min.*	*sec.*	*g.*	
Holstein:	mastitis	2.33	6.66	5	42	31	64
	non-mastitis	2.28	6.53	3	30	57	68
	entire group	2.32	6.59	4	18	39	188
Jersey:	mastitis	2.90	6.65	5	36	93	31
	non-mastitis	2.69	6.49	2	30	109	55
	entire group	2.81	6.56	3	30	98	121

[1] Determined by the formol titration method.

the coagulation time was long in the mastitis milk, the average percentage of casein as determined by the formol titration method was actually slightly higher in mastitis milk than in normal milk. The above evidence as to percentage of casein may not be considered as conclusive, however, since the formol titration method is considered accurate for estimating amino groups rather than casein, and may be properly used for estimating the percentage of casein only in milk of normal composition. There is a reasonable doubt whether mastitis causes as great a decrease in percentage of casein as has been generally believed. In further work now under way preliminary to a

more detailed study of the effects of mastitis upon milks, analyses of samples from each quarter of mastitis-infected udders have shown in some cases a decrease and in some cases an increase in percentage of casein, as determined by the official method, in mastitis milks as compared with normal milks.

In order to consider the changes which took place during an elapsed time of three months, as a result of mastitis, data were tabulated from tests of samples from those cows which either acquired mastitis during this period or which showed increased symptoms of the disease. On this basis it was found that the presence of mastitis was accompanied by a distinct increase in the pH values of the milks, and increase in the rennet curdling time in 96 per cent of the milks, and a reduction in the firmness of rennet curd in 60 per cent and in the Hill curd tension in 56 per cent.

The cows showing evidences of chronic mastitis produced milk of high pH value, long curdling time, and soft curd. There was a tendency for the properties of mastitis milks to return to normal when the bacteriological and pathological evidences of the infection subsided. Some soft-curd milks were found in which no evidences of mastitis were present.

SUMMARY

In experiments on over 300 samples of milk the following observations were made:

The Hill curd test was found not satisfactory for determining the firmness of curd in milk to be used for making cheese. The rennet curd tension as measured by means of the Hill Curd-O-Meter was entirely suitable for this purpose, and the determination of rennet coagulation time was fairly satisfactory.

The pH values of milks bore a very definite relation to the rennet coagulation time and to the rennet curd tension, and bore a less definite relation to the Hill curd tension. The pH seemed to be a major factor in influencing the rennet coagulation time, while the percentage of casein was found to be more important in influencing the rennet curd tension.

Milks stable to rennet were usually stable to alcohol. Stability to both rennet and alcohol was increased when milk was stored at 2° to 5° C. for from a few hours to several days. Stability to both rennet and alcohol was decreased by the addition of $CaCl_2$.

Homogenization markedly decreased the rennet curd tension of whole milk but did not change that of skimmilk; this process did not change the rennet coagulation time of either whole or skimmilk. Removal of milk fat by separation increased the rennet curd tension and caused a slight increase rather than a decrease in the rennet coagulation time. These observations lead to the conclusion that the curd-softening effect of homogenization is due principally to an increase in the dispersion of the fat, the dispersed fat

acting as a physical hindrance to the aggregation of the casein molecules and micellae.

Pasteurization caused a noticeable softening of milk curd and caused a slight increase in rennet coagulation time.

The presence of mastitis caused an increase in pH, an increase in rennet coagulation time, and a decrease in rennet curd tension.

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THE EFFECT OF EARLY BREEDING UPON THE MILK ENERGY PRODUCTION OF GRADE AND PUREBRED TOGGENBURG GOATS

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Goats are destined perhaps to be used more and more in fundamental research problems. They are the smallest animals from which milk and milk fat records may be determined directly and with convenience. They are ruminants. In so far as feed cost is concerned, five to six or seven does may be maintained for the same cost as one cow. The length of the lactation period is about the same as that for dairy cows. The number of generations of females, as well as the total number of females, that can be produced in a given time is greater with goats than with cattle, because of the frequency of twins and triplets in goats and the fact that females born with males will breed in the case of goats.

Addington and Cunningham (1) found that Toggenburg does over 18 months of age at parturition produce offspring at the rate of about 2,100 kids for each 1,000 pregnancies, and that yearling does, under 18 months of age at parturition, produce offspring at the rate of about 1,500 kids per 1,000 pregnancies.

Goats may be bred to kid the first time at 12 or 13 months of age and again at the age of two years. If this practice could be followed without detrimental effect upon the does, the number of generations of animals that could be raised in a given period would be materially increased. However, many goat breeders have insisted that the does should not be bred to kid for the first time until they are at or near two years of age.

EXPERIMENTAL RESULTS

The published records of twenty-two pairs of full sisters are available in the appendix of (1), pp. 78 to 80, inclusive, and furnish the material for the discussion in this study.

One member of each pair of these twenty-two pairs of full sisters kidded for the first time at or near two years of age. The other member of each pair kidded for the first time when between 11 and 14 months of age and again at or near two years of age. The milk and fat produced by the two members of each pair were converted to the equivalent amount of 4% milk as calculated by the formula of Gaines and Davidson (3), (5).

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TABLE 1

A comparison by student's method of the amounts of 4% milk produced by the members of 22 full sister pairs of purebred and grade Toggenburg does in lactations begun at or near two years of age

(1) Production of 4% milk by does freshening for first time at two years of age.
(2) Production of 4% milk by does freshening as yearlings and again at two years.

HERD NOS. OF PAIRS	(1) 4% MILK	(2) 4% MILK	D OR 1–2	D^2 OR $(1-2)^2$
	pounds	*pounds*		
37–36	927.9	1630.0	– 702.1	492,944.4
37–20	927.9	814.5	113.4	12,859.6
170–104	1039.8	1022.4	17.4	302.8
172–111	906.5	1314.5	– 408.0	166,464.0
173–111	892.9	1314.5	– 421.6	177,746.6
31–16	1172.0	902.4	269.6	72,684.2
31–30	1172.0	1180.9	– 8.9	79.2
43–100	827.5	1211.1	– 383.6	147,149.0
121–264	1181.0	1021.7	159.3	25,376.5
34–35	1132.5	921.5	211.0	44,521.0
53–112	1119.8	1400.0	– 280.2	78,521.0
304–303	1394.3	1220.6	173.7	30,171.7
29–12	851.5	1216.3	– 364.8	133,079.0
29–18	851.5	1043.9	– 192.4	37,017.8
29–28	851.5	1435.9	– 584.4	341,523.4
24–21	905.3	957.6	– 52.3	2,735.3
24–25	905.3	1066.3	– 161.0	25,921.0
32–33	786.5	1374.3	– 587.8	341,523.4
23–19	1148.1	945.3	202.8	41,127.8
167–109	1206.4	1240.2	– 33.8	1,142.4
307–306	1565.6	1346.2	219.4	48,136.4
307–422	1565.6	1427.1	138.5	19,182.3
Total	23331.4	26007.2	– 2675.8	2,244,185.2
Means	1060.5	1182.1	– 121.6	102,008.4

$$\text{S. D.} = \sqrt{102{,}008.4 - (-121.6)^2} = 293.3$$

$$\frac{\text{M}}{\text{S. D.}} = \text{Z} = \frac{-121.6}{293.3} = -.415.$$

$$\text{Odds} = 26.8 : 1$$

The data for twenty-two pairs of full sisters have been compared by Student's Method (4) as shown in table 1. The first column in this table gives the herd numbers for the two full sisters of each pair. The second column shows the production of 4% milk for the member of each pair that freshened for the first time at or near two years of age. The third column shows the production of 4% milk by the member of each pair that kidded for the second time at or near two years of age. The fourth column shows the difference between the second and third columns, while the fifth and last column shows the squares of the differences given in column four.

The mean production of 4% milk for the does freshening for the first time at or near the age of two years was 1060.5 pounds, and that for the does freshening for the second time at or near two years of age was 1182.1 pounds. The Z value was found to be – .415, which for twenty-two pairs gives odds of 26.8 : 1 that there is a significant difference between the production of the two groups of does in favor of those that freshened for the second time at or near two years of age.

Either one or both members of 17 of the 22 pairs of does were disposed of, so that records when freshening at or near three years of age for only

TABLE 2

A comparison by student's method of the length of the lactation periods of the members of twenty-two full sister pairs of purebreed and grade Toggenburg does in lactations begun at or near two years of age

(1) Days of lactation of does freshening first time at two years of age.
(2) Days of lactation of does freshening as yearlings and again at two years of age.

HERD NOS. OF PAIRS	(1) DAYS	(2) DAYS	D OR 1–2	D^2 OR $(1–2)^2$
37–36	292	297	13	169
37–20	292	218	74	5,476
170–104	247	256	– 9	81
172–111	279	292	– 13	169
173–111	254	292	– 38	1,444
31–16	292	237	55	3,025
31–30	292	296	– 4	16
43–100	309	258	51	2,601
121–246	262	304	– 42	1,764
34–35	269	293	– 24	576
53–112	310	275	35	1,225
304–303	305	309	– 4	16
29–12	293	290	3	9
29–18	293	222	71	5,041
29–28	293	295	– 2	4
24–21	299	264	35	1,225
24–25	299	297	2	4
32–33	295	294	1	1
23–19	285	230	55	3,025
167–109	271	280	– 9	81
307–306	305	305	0	0
307–422	305	305	0	0
Total	6,341	6,091	250	25,952
Mean	288	277	11	1179.6

$$\text{S. D.} = \sqrt{1179.6 - (11)^2} = 32.5.$$

$$Z = \frac{M}{\text{S. D.}} = \frac{11}{32.5} = .34$$

Odds = 13.26 : 1.

5 of the pairs are available for further comparison. The mean production of 4% milk for the 5 does freshening for the second time, at the approximate age of 3 years, was 1453.8 pounds; while that for the 5 does freshening for the third time, at approximately 3 years of age, was 1570.1 pounds. The Z value was – .419, but since there were only 5 pairs, the odds by Student's Method are 3.46 : 1 that the difference was significant. While the difference is certainly not a significant one, it is in favor of the does freshening as yearlings, 2-year-olds, and again as 3-year-olds.

Except for three does that were milked for slightly longer periods, the lactation period for each of the does was continued until the goat was dry or practically so, or until 305 days were reached. The data for the length of the lactation periods were analyzed by the use of Student's Method (4) as shown in Table 2. The mean lengths of the lactation periods at two years of age were 288 and 277 days, respectively, for the does freshening for the first time at or near two years of age and those freshening for the second time at or near two years of age. The odds are 13.26 : 1 that the difference between the lengths of the lactation periods is significant. Odds of 25 to 30 : 1 are required to establish a definite difference.

Practically all of the does in this experiment that freshened at or near one year of age were milked for a comparatively short lactation period, usually five to seven months, following the earlier kidding. Thus, a comparatively long period between the first and second kidding was allowed for growth, unhampered by lactation. Dr. Eckles (2) has pointed out that the production of milk is a much more severe drain upon an animal's system than is the growth of a foetus.

SUMMARY AND CONCLUSIONS

The production of 4% milk and the length of the lactation period following a freshening at or near two years of age have been compared for twenty-two pairs of full sisters of grade and purebred Toggenburg milk goats. One member of each pair freshened for the first time at or near two years of age and the other member of each pair freshened at or near one year of age and again at or near two years of age.

The odds, by Student's Method, of 26.8 : 1 are in favor of the does that freshened as yearlings and again as two-year-olds. While the odds are not great enough to show a very significant difference, the tendency is to favor the does that freshened for the second time at or near two years of age. This is in direct contrast to the belief held by a large number of goat breeders.

The mean difference in the length of the lactation period was eleven days and was in favor of the does that freshened for the first time at or near two years of age, with odds of 13.26 : 1 that the difference is significant. Again

the odds are not great enough to show a definitely significant difference, but the tendency is to favor the does freshening for the first time at or near two years of age.

Under the conditions of this experiment, it is feasible to increase the number of generations of female goats that can be secured in a long-time breeding experiment by having the does freshen for the first time when eleven to fourteen months of age, at least when no attempt is made to milk the yearlings for a full lactation period of ten months.

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(1) ADDINGTON, L. H., CUNNINGHAM, O. C. Milk goat breeding. N. Mex. Agr. Expt. Sta. Bul. 229. 1935.

(2) ECKLES, CLARENCE H. Dairy cattle and milk production. Pp. 290–292 especially. 1931.

(3) GAINES, W. L., AND DAVIDSON, F. A. Relation between percentage fat content and yield of milk. Correction of milk yield for fat content. Ill. Agr. Expt. Sta. Bul. 245. June, 1923.

(4) LOVE, H. H. A modification of Student's Table for use in interpreting experimental results. Jour. Amer. Soc. of Agron. 16: 68–73. 1924.

(5) OVERMAN, O. R., AND GAINES, W. L. Milk-energy formulas for various breeds of cattle. Jour. Agr. Res. 46: 1109–1120.

AMERICAN DAIRY SCIENCE ASSOCIATION

The Thirty-first Annual Meeting

State College, Pennsylvania, June 15–19, 1936

GENERAL PROGRAM

Monday, June 15

1 P. M.–9 P. M.	General Registration and room registration, Dairy Building.

Tuesday, June 16

8 A. M.–9 P. M.	General Registration and room registration, Dairy Building.
9 A. M.–12 NOON	Dairy cattle judging conference.
	DEMONSTRATION
	Dairy type and milk production in relation to antemortem and post mortem weights and measurements.
	Palpation of calf udders to demonstrate the various stages of development of the mammary gland.
	W. W. Swett, Bureau of Dairy Industry, U. S. Department of Agriculture, assisted by members of the Penn State dairy staff.
12 NOON–1 P. M.	Lunch hour.
1 P. M.–4 P. M.	Extension Section Meeting, Room 117, Dairy Building.
1:30 P. M.–4:30 P. M.	Ice Cream Judging Conference, Room 120, Creamery Building.
	William White, Chairman, Bureau of Dairy Industry.
	A. C. Dahlberg, Judge, New York Agricultural Experiment Station, Geneva.
4 P. M.	Board of Directors' Meeting, Room 209, Dairy Building.
7:30 P. M.	Opening Session, College Auditorium, Central Campus.
	President H. A. Ruehe, presiding.
	Address of Welcome:
	Dr. R. L. Watts, Dean of the School of Agriculture, and Director of the Experiment Station.
	Address by the President of the Association.
	Dr. H. A. Ruehe, University of Illinois.
	Business.

8:30 P. M. Informal social get-together for members, guests and their families, 2nd floor lounge, Old Main Building, Central Campus.

Wednesday, June 17

8 A. M.–12 NOON General Registration and room registration, Dairy Building.

9 A. M.–4 P. M. Complimentary mountain tour for wives, young folks, and children of registrants. See the mountain laurel in bloom and visit Alexander Caverns. Standard buses will provide safety and comfort. Luncheon at Greenwood Forest Camp. Tickets at registration. Assemble in front of Dairy Building.

8 A. M.–9 A. M. Sectional Committee Meetings.
Production, Room 8, Dairy Building.
Manufacturing, Room 110, Home Economics Building, East Campus.
Committee on chemical methods for the analysis of milk and dairy products, Rooms 3 and 4, Dairy Building.

9 A. M.–12 NOON General Session, College Auditorium, Central Campus.
President H. A. Ruehe, presiding.
National Survey of Sediment Testing of Cream and Butter.
G. F. Stewart and M. E. Parker, Research Committee, American Association of Creamery Butter Manufacturers.
Science and Practical Dairying.
W. J. Fraser, University of Illinois.
Making Research Pay in the Dairy Business.
J. L. Kraft, President, Kraft-Phenix Cheese Corporation, Chicago.
Notice: MEN Wanted.
W. V. Dennis, Professor of Rural Sociology, The Pennsylvania State College.
Business.

12 NOON–1 P. M. Complimentary Dairy Lunch, 120 Creamery Building.

1 P. M.–4 P. M. Production Section, Room 8, Dairy Building.

1 P. M.–4 P. M. Manufacturing Section, Room 110, Home Economics Building, East Campus.

4 P. M.–5 P. M. Sectional Committee Meetings.
Production, Room 8, Dairy Building.
Manufacturing, Room 110, Home Economics Building, East Campus.
Extension, Room 117, Dairy Building.

Committee on chemical methods for the analysis of milk and dairy products, Rooms 3 and 4, Dairy Building.

4 P. M.–5 P. M. See places of interest on the campus.
Respiration calorimeter for large animals.
Jordan Fertilizer Plots (oldest in America).
Mineral Industries exhibit.
Staff members of the departments concerned will be present at the points of interest during this period.

6:30 P. M. Complimentary dinner for registrants and their wives, McAllister Hall. Tickets at registration.

6:30 P. M. Complimentary dinner, under supervision, for young folks and children, Sandwich Shop, Old Main. Tickets at registration.

Thursday, June 18

8 A. M.–10 A. M. Extension Exhibits, Room 201, Dairy Building.

9 A. M.–12 NOON Production Section, Room 8, Dairy Building.

9 A. M.–12 NOON Manufacturing Section, Room 110, Home Economics Building, East Campus.

9 A. M.–12 NOON Children and young folks program.
Supervised play, municipal playground, or mountain hike for those who prefer it. Assemble in front of Old Main Building.

10 A. M. For ladies—Places of interest on the campus.
Old Main Tower.
Home Economics Building.
Mineral Industries Exhibits.
Rose Gardens adjacent Dairy Building.
Golf for those who prefer it.

12 NOON–1 P. M. Lunch hour.

1 P. M.–2 P. M. Sectional Business Meetings.
Production, Room 8, Dairy Building.
Manufacturing, Room 110, Home Economics Building, East Campus.
Extension, Room 117, Dairy Building.

2 P. M.–4 P. M. Extension Section, Room 117, Dairy Building.

2 P. M.–4:30 P. M. Production Section, Room 8, Dairy Building.

2 P. M.–4:30 P. M. Manufacturing Section, Room 110, Home Economics Building, East Campus.

2 P. M.–4 P. M. Children and young folks program.
Swimming at the Glennland Pool, Pugh Street and Beaver Avenue. Exclusive use of pool reserved. Admission by complimentary ticket at registration.

2 P. M.–4 P. M. Entertainment for ladies at The Nittany Lion Inn, West Campus. Complimentary tickets at registration.

6:30 P. M. Subscription banquet, McAllister Hall. Tickets to be purchased at registration.

Friday, June 19

8 A. M.–9 A. M. General Business Session, College Auditorium, Central Campus.

9 A. M.–12:30 P. M. Production Section, Room 8, Dairy Building.

9 A. M.–12:30 P. M. Manufacturing Section, Room 110, Home Economics Building, East Campus.

12:30 P. M.–1:30 P. M. Lunch hour.

2 P. M. Optional tours—Transportation not furnished.

Kylertown pasture fertilizer experiment in cooperation with the U. S. Bureau of Plant Industry. Located 34 miles north of State College on Pa. Route 53.

Fisherman's Paradise, 6 miles northeast of State College.

U. S. Dairy Bureau, Washington, D. C. Members of the Bureau will entertain visitors at the Laboratories in Washington and at the farm at Beltsville, Md., on Saturday morning, June 20, at 9:00 o'clock.

SECTION PROGRAMS

EXTENSION SECTION

E. J. PERRY, *Chairman*
Tuesday afternoon, June 16

Dairy Building, Room 117

1:00–2:30—TESTING COMMITTEE REPORTS

FLOYD JOHNSTON, *Chairman*
(Papers limited to 10 minutes)

E1—Securing qualified cow testers for dairy herd improvement associations. C. R. Gearhart, Pennsylvania State College.

E2—Dairy herd improvement association supervisor's conferences. M. J. Regan, University of Missouri.

E3—Combining farm accounts with D. H. I. A. records. E. A. Gauntt, New Jersey College of Agriculture.

E4—The county agricultural agent's responsibility in connection with a testing program. G. E. Gordon, University of California.

E5—Handling herd improvement and advance registry testing in connection with herd improvement testing associations. Floyd Johnston, Iowa State College.

2:30–4:00—SIRE COMMITTEE REPORTS

J. F. KENDRICK, *Chairman*

E6—Conducting a bull association program. S. J. Brownell, New York College of Agriculture.

E7—The future dairy herd improvement association sire program. E. E. Heizer, Ohio College of Agriculture, and J. F. Kendrick, Bureau of Dairying, United States Department of Agriculture.

E8—Dairy herd analysis and proved sire work. E. H. Loveland, Vermont College of Agriculture, and R. G. Connelly, Virginia College of Agriculture.

PRODUCTION SECTION

Wednesday afternoon, June 17, 1:00–4:00 o'clock

Dairy Building, Room 8

K. S. MORROW, *Chairman*

GENETICS, MASTITIS, NUTRITION

(Papers limited to 10 minutes)

P1—Relative genetic worth of partial lactation records of various lengths. W. L. Gaines, University of Illinois.

P2—Heritability of butterfat percentage and butterfat production in the data with which sires have been proved in Iowa. Jay L. Lush and Earl N. Shultz, Iowa State College.

P3—Some results of eighteen years of close breeding with Jerseys. W. M. Regan, S. W. Mead and P. W. Gregory, University of California.

P4—Evaluating inheritance for type from grades. W. W. Swett, Bureau of Dairy Industry, U. S. D. A.

P5—Some additional findings of the dairy cattle germ plasm survey. M. H. Fohrman, Bureau of Dairy Industry, U. S. D. A.

P6—A report on a control program for bovine infectious mastitis based on segregation of infected animals. E. O. Anderson and W. N. Plastridge, Connecticut Agricultural College, Storrs.

P7—Studies on aseptically drawn milk from Bang's disease positive and Bang's disease negative cows. H. B. Morrison and F. E. Hull, University of Kentucky.

P8—Two types of blindness in cattle and their possible relation to vitamin deficiency. A. H. Kuhlman, W. D. Gallup and E. Weaver. Oklahoma A. and M. College.

P9—Production of white spotted kidneys in calves. L. A. Moore and E. T. Hallman, Michigan State College.

P10—Tuberculosis in milk goats. O. C. Cunningham and L. H. Addington, New Mexico A. and M. College.

P11—Vitamin A replaces whole milk in the calf ration. H. T. Converse and Edward B. Meigs, Bureau of Dairy Industry, U. S. D. A.

P12—Supplementing a normal ration for dairy calves with cod liver oil. P. M. Reaves, Virginia Polytechnic Institute, and C. Y. Cannon, Iowa State College.

P13—The physiological effect of a hegari fodder and cottonseed meal ration on dairy cows. O. C. Cunningham, L. H. Addington and E. M. Lantz, New Mexico State College.

4:00–4:30—Sectional Committee Meetings.

MANUFACTURING SECTION

Wednesday afternoon, June 17, 1:00–4:30 o'clock

Home Economics Buiding

L. M. THURSTON, *Chairman*

VITAMINS—CHEMISTRY—TECHNIQUES

(Papers limited to 10 minutes)

M1—Results obtained when the several Minnesota reagents were employed for testing buttermilk. D. F. Breazeale and E. W. Bird, Iowa State College.

M2—The effect of preservatives on the results obtained with ice cream mixes by several testing methods. P. H. Hostetler, C. A. Iverson and E. W. Bird, Iowa State College.

M3—The determination of citric acid in milk. H. L. Templeton, University of Wisconsin.

M4—Vitamin C content of milk. C. H. Whitnah and W. H. Riddell, Kansas Agricultural College.

M5—Vitamin C content of dairy orange beverages. M. J. Mack, C. R. Fellers, W. A. Maclinn and D. A. Bean, Massachusetts State College.

M6—Catalytic destruction of vitamins by manganese during the pasteurization process. A. D. Pratt, Virginia A. and M. College.

M7—X-ray diffraction studies of cheese protein during the ripening of Cheddar cheese. S. L. Tuckey, H. A. Ruehe and G. L. Clark, University of Illinois.

M8—The relation of the oxidation-reduction potential of milk to oxidized flavor. R. E. Webb and J. L. Hileman, Dairymen's League Laboratories.

M9—Some observations on the electrokinetic potential of milk fat. E. L. Jack and C. D. Dahle, Pennsylvania State College.

M10—A new type of quinhydrone electrode for directly determining the hydrogen-ion concentration of cheese and other materials. George P. Sanders and E. O. Whittier, Bureau of Dairy Industry, U. S. D. A.

M11—An improved motor driven curd tester. L. A. Chambers, University of Pennsylvania, Philadelphia.

M12—Use of a dynamic foam meter for measuring foaming ability of ice cream mixes. J. L. Minkin and J. H. Erb, Ohio State University.

4:00–4:30 Sectional Committee Meetings.

EXTENSION SECTION

Thursday morning, June 18

Dairy Building, Room 201

E. J. PERRY, *Chairman*

8:00–10:00 Extension Exhibits.

C. R. Gearhart, *Chairman*
C. J. Fawcett, Massachusetts
J. G. Hayes, Michigan
E. A. Hanson, Minnesota
R. T. Keithley, Virginia

Exhibits from several states showing Dairy Extension methods in teaching will be on display with explanatory labels during the entire meeting. The above committee and specialists will be present during this period to discuss and explain the exhibits from their own state.

PRODUCTION SECTION

Thursday morning, June 18, 9:00–12:00 o'clock

Dairy Building—Room 8

K. S. MORROW, *Chairman*

NUTRITION (Continued)—VITAMINS

(Papers limited to 10 minutes)

P14—The vitamin A requirements of dairy cows for reproduction and lactation under practical conditions. E. B. Meigs and H. T. Converse, Bureau of Dairy Industry, U. S. D. A.

P15—Reproduction of dairy cows on a ration of prairie hay and cottonseed meal. A. H. Kuhlman, E. Weaver and A. Nalbandov, Oklahoma A. and M. College.

P16—The effect of sprouted oats on reproduction of dairy cattle. H. P. Davis and I. L. Hathaway, University of Nebraska.

P17—Magnesium carbonate and magnesium oxide supplements to a whole milk ration for dairy calves. C. F. Huffman and C. W. Duncan, Michigan State College.

P18—Gross and microscopic pathology associated with low blood magnesium in dairy calves. L. A. Moore, L. B. Sholl and E. T. Hallman, Michigan State College.

P19—Cod liver oil and muscle dystrophy in calves. G. Davis and L. A. Maynard, Cornell University.

P20—Effect of phosphorus intake on the calcium and inorganic phosphorus content of whole blood of dairy heifers during the periods of gestation and first lactation. A. H. Van Landingham, H. O. Henderson and G. A. Bowling, University of West Virginia.

P21—Relative utilization by dairy cows of calcium and phosphorus in dicapho (dicalcium phosphate) and bonemeal (tricalcium phosphate). J. A. Newlander, H. B. Ellenberger and C. H. Jones, University of Vermont.

P22—Body analyses of dairy cows after long time calcium and phosphorus balance trials. H. B. Ellenberger, J. A. Newlander and C. H. Jones, University of Vermont.

P23—The influence of roughage on the vitamin D potency of milk. G. C. Wallis and T. M. Olson, South Dakota State College.

P24—A further study of the factor in soybeans affecting the vitamin A value of butter. S. M. Hauge, J. W. Wilbur and J. H. Hilton, Purdue University.

P25—The rate of change in the vitamin A content of milk. W. C. Loy, J. H. Hilton, J. W. Wilbur and S. M. Hauge, Purdue University.

MANUFACTURING SECTION

Thursday morning, June 18, 9:00–12:00 o'clock

Home Economics Building

L. M. THURSTON, *Chairman*

MARKET MILK

(Papers limited to 10 minutes)

M13—Milk inspection work in the United States. T. B. Harrison, University of Tennessee.

M14—A study of the abnormal relationship of fat to solids-not-fat in milk. H. C. Moore and K. S. Morrow, University of New Hampshire.

M15—Quality—composition relationships in goats milk. J. C. Marquardt, New York Agricultural Experiment Station, Geneva.

M16—Observations on the development of rancidity in sweet milk, cream and butter. E. L. Fouts and E. Weaver, Oklahoma A. & M. College.

M17—Concerning the cause of rancid and oxidized flavors of bovine origin. J. A. Anderson, Rutgers University, J. G. Hardenbergh and L. T. Wilson, Walker-Gordon Laboratory.

M18—Study of the causes of bitter flavor in cream. L. J. Manus and L. M. Thurston, West Virginia University.

M19—The activatability of milk with ultra-violet light. W. E. Krauss, R. M. Bethke and R. G. Washburn, Ohio Experiment Station, Wooster.

M20—The effects of feeding ergosterol to cows on the activatability of the milk. R. F. Light, L. T. Wilson and C. N. Frey, Fleischmann Laboratories, New York, and Walker-Gordon Laboratory.

M21—Treatment of milk previous to separation and the effect on viscosity of market cream. H. B. Henderson and H. B. Ellenberger, University of Vermont.

M22—A study of the adaptability of the vacuum seal for milk bottles. W. H. Brown, P. H. Tracy and M. J. Prucha, University of Illinois.

M23—Instant whipping of cream by aeration. G. A. Getz, G. F. Smith and P. H. Tracy, University of Illinois.

M24—The influence of method of sterilizing equipment upon the development of oxidized flavor in milk. A. C. Dahlberg and D. C. Carpenter, New York Agricultural Experiment Station, Geneva.

EXTENSION SECTION

Thursday afternoon, June 18

Dairy Building, Room 117

E. J. PERRY, *Chairman*

1:00–2:00—SECTION BUSINESS MEETING

2:00–3:00—FEEDING COMMITTEE REPORTS

A. R. MERRILL, *Chairman*

(Papers limited to 10 minutes)

(These papers are presented with a view of applying the facts to an Extension teaching program.)

E9—Alfalfa-molasses silage *vs.* alfalfa hay as a roughage for lactating dairy cows. Russell E. Horwood, Michigan State College.

E10—Calf starters fed dry with limited whole milk. E. S. Savage, New York College of Agriculture.

E11—Sudan grass and sweet clover as temporary pasture crops. R. A. Acherman and H. O. Henderson, West Virginia College of Agriculture.

E12—Summer decline in milk production. H. O. Wales, J. W. Linn and F. W. Atkeson, Kansas State College.

E13—Feeding more roughage to dairy cows. C. F. Huffman, Michigan State College.

3:00–4:00—CALF CLUB COMMITTEE REPORTS

DWIGHT M. SEATH, *Chairman*

E14—4-H Dairy Club work as a dairy extension project. J. Nageotte, Pennsylvania State College.

E15—4–H Club junior bull rings. M. L. Flack, University of Nebraska.
E16—Dairy projects for older boys. E. N. Shultz, Iowa State College.
E17—The 4–H classification at the national dairy show. D. M. Seath, Kansas State College.

PRODUCTION SECTION

Thursday afternoon, June 18, 1:00–4:30 o'clock

Dairy Building, Room 8

K. S. Morrow, *Chairman*

MILK SECRETION, A. I. V. SILAGE, TECHNIQUES

(Papers limited to 10 minutes)

1:00–2:00—Sectional Business Meeting.
P26—Site of synthesis of fat in the mammary gland. P. Kelly and W. E. Petersen, University of Minnesota.
P27—Galactin content of pituitaries. R. P. Reece and C. W. Turner, University of Missouri.
P28—Bovine ovarian reactions to various gonadotropic hormone preparations. L. E. Casida, University of Wisconsin.
P29—Comparisons of arterial and mammary venous bloods as related to milk secretion. W. R. Graham, Jr., University of Missouri and National Institute for Research in Dairying, Reading, England.
P30—Effect of hypophysectomy on development and function of the mammary gland. E. T. Gomez and C. W. Turner, University of Missouri.
P31—The vitamin A Content of A. I. V., molasses and normal silage and the effect of feeding these silages upon the vitamin A content of milk. I. L. Hathaway, H. P. Davis and J. C. Brauer, University of Nebraska.
P32—Studies on A. I. V. silage, Part I—Preparation and feeding. C. F. Monroe and C. C. Hayden, Ohio Agricultural Experiment Station, Wooster.
P33—Studies on A. I. V. silage, Part II—Nutrient preservation and physiological effects on the cow. A. E. Perkins and C. F. Monroe, Ohio Agricultural Experiment Station, Wooster.
P34—Studies on A. I. V. silage, Part III—Carotene preservation and biological properties of the milk. W. E. Krauss and R. C. Washburn, Ohio Agricultural Experiment Station, Wooster.
P35—Photographic techniques as applied to the dairy industry. R. F. Morgan, University of Nebraska.
P36—Alignment charts for estimating profit per cow and per unit milk. S. Brody and A. C. Ragsdale, University of Missouri.
P37—A lesson in feeds. R. B. Becker, University of Florida.

MANUFACTURING SECTION

Thursday afternoon, June 18, 1:00–4:30 o'clock

Home Economics Building, Room 110—East Campus

L. M. THURSTON, *Chairman*

BACTERIOLOGY

(Papers limited to 10 minutes)

1:00–2:00—Section business meeting.

M25—Modified medium and incubation temperatures as they affect bacteria counts of milk containing organisms arising from various sources of contamination. A. Bradfield and H. B. Ellenberger, University of Vermont.

M26—The present status of the proposal to change the composition of the agar and temperature of incubation of the standard agar plate technic of the American Public Health Association. R. S. Breed, New York Experiment Station, Geneva.

M27—*Streptococcus lactis* in raw and pasteurized milks of very high quality. E. S. Yawger and J. M. Sherman, Cornell University.

M28—The characteristics of freshly isolated cultures of *Lactobacillus bulgaricus*. J. M. Sherman and H. M. Hodge, Cornell University.

M29—The heat resistance of colon organisms in milk. C. N. Stark and Mary C. Patterson, Cornell University.

M30—The significance of bacterial and chemical changes occurring in mastitis milk and their correlation with milk production. L. A. Burkey, G. P. Sanders and J. F. Cane, Bureau of Dairy Industry, U. S. D. A.

M31—Frequency of the *Escherichia-aerobacter* species in commercial butter. E. H. Parfitt, Purdue University.

M32—A comparison of media used for determining the bacterial content of ice cream. F. J. Babel and E. H. Parfitt, Purdue University.

M33—The effect of certain Penicillia on the volatile acidity and the flavor of Iowa blue cheese (Roquefort type). C. B. Lane, Iowa State College.

M34—Sanitary aspects of homogenized milk. M. J. Prucha and P. H. Tracy, University of Illinois.

PRODUCTION SECTION

Friday morning, June 19, 9:00–12:30 o'clock

Dairy Building—Room 8

K. S. MORROW, *Chairman*

SILAGE—RATIONS—HAY

(Papers limited to 10 minutes)

P38—Production of dairy cows when fed only silage and cracked soybeans. N. K. Williams, C. Y. Cannon and D. L. Espe, Iowa State College.

P39—Methods of making grass silage. T. E. Woodward, Bureau of Dairy Industry, U. S. D. A.

P40—Sweet potatoes *versus* silage for milk production. R. H. Lush, Louisiana Agricultural Experiment Stations.

P41—Soy bean hay as the sole roughage for dairy cows. L. F. Herrman and G. A. Bowling, West Virginia University.

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P49—Effect of moisture content and density of stored roughage on temperatures attained during storage and the quality of the product. J. B. Shepherd, T. E. Woodward and R. R. Graves, Bureau of Dairy Industry, U. S. D. A.

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MANUFACTURING SECTION

Friday morning, June 19, 9:00–12:30 o'clock

Home Economics Building

L. M. THURSTON, *Chairman*

CHEESE—BUTTER—ICE CREAM

(Papers limited to 10 minutes)

M35—Wrappers for processed cheese. H. L. Templeton, University of Wisconsin.

M36—A study of inexpensive milk pasteurizing units for cheese factories. W. V. Price, University of Wisconsin.

M37—Salting and cooking curds in the manufacture of several varieties of cheese. J. C. Marquardt, New York Agricultural Experiment Station, Geneva.

M38—The influence of salt on the composition and quality of brick cheese. E. L. Byers and W. V. Price, University of Wisconsin.

M39—The utilization of whey in the preparation of some new food products. B. H. Webb and G. A. Ramsdell, Bureau of Dairy Industry, U. S. D. A.

M40—A pasteurizing difficulty experienced where whey cream is processed. L. C. Thomsen, University of Wisconsin.

M41—A summary of results of experimental studies of certain factors affecting churning losses. H. A. Derby, D. F. Breazeale, and E. W. Bird, Iowa State College.

M42—A preliminary report of the effect of certain neutralizers on the churning loss and the keeping quality of butter. N. E. Fabricus, D. F. Breazeale and E. W. Bird, Iowa State College.

M43—Some factors influencing the spreadability of butter. S. T. Coulter and W. B. Combs, University of Minnesota.

M44—A proposed score card for judging churning cream. L. H. Burgwald and J. H. Erb, Ohio State University.

M45—A comparison of pressure and centrifugal homogenization of ice cream mixes. J. C. Hening, New York Agricultural Experiment Station, Geneva.

M46—The use of sodium alginate as a stabilizer in ice cream. P. H. Tracy, G. L. Gibson and S. L. Tuckey, University of Illinois.

M47—Recent studies on the use of dextrose in ice cream. W. J. Corbett and P. H. Tracy, University of Illinois.

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SPECIAL PUBLICATIONS

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State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copenhagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE ON MILK AND MILK PRODUCTS

BUTTER

Intensifying Flavor and Aroma in Butter. H. A. Ruehe and R. J. Ramsey, Dept. of Dairy Husbandry, Univ. of Illinois, Urbana, Ill. Milk Plant Monthly, *24*, 2, p. 40, Feb., 1935.

The flavoring principles of starter (diacetyl and certain volatile products) were removed by steam distillation. When the distillate was added to cream the flavor and aroma of the cream were increased without increasing the acidity. Such treated cream yielded a butter of high aroma similar to ripened cream butter, yet the butter was low in acidity.

Starters to be used for distillation can be made to produce several times the normal amount of flavoring substances. G.M.T.

CHEESE

The Prevention of Some Common Defects in Cottage Cheese. W. V. Price, Univ. of Wisconsin, Madison, Wis. The Milk Dealer, *24*, 6, p. 46, March, 1935.

Sour flavor: Appearing immediately after manufacture may be due to the presence of too much whey in the curd, due to low temperatures of cooking, to lack of firming of the curd before draining, or to lack of draining of the curd before washing.

When the curd turns sour in storage, the defect may be attributed to too much moisture in the curd, improper washing, holding at unsuitable temperatures, holding for too long a period, or the wrong kind of starter. Too much moisture in the curd can be corrected by heating to a higher temperature and firming the curd before draining off the whey. Improper washing may be due to applying the water before all the whey is removed, to the use of too small an amount of water, or to incomplete draining away of the wash water. To inhibit the growth of bacteria, a storage temperature of 32° to 35° F. should be used. A starter which persistently develops more than 0.80 per cent of acid in the mother culture in a period of 16 hours at 70° F. should be discarded.

Fermented, yeasty, and bitter flavors: Commonly caused by the growth of certain micro-organisms which may be found in the cheese because (1) raw milk was used, (2) the milk was improperly pasteurized, (3) of the use of inferior starter, (4) too much whey in the curd or improper washing of the curd, (5) improper storage conditions, or (6) unclean equipment.

Only properly pasteurized milk should be used in making cottage cheese. Starters should be carefully watched for the first indications of undesirable

flavor, weakness or inactivity, and should be discarded when such signs appear. Cottage cheese is almost as perishable as milk or cream under the same storage conditions. Strict cleanliness, efficient scalding or sterilization with chlorine solutions, and drying of equipment and utensils are as necessary in the manufacture of cottage cheese as in handling milk of high quality.

Unclean flavors: May be caused by lack of cleanliness, by conditions of manufacturing, by feed, or by storage conditions. Every precaution should be taken to select milk with a clean flavor for the production of cottage cheese. Strict cleanliness and adequate sterilization are essential. If milk free from feed flavors cannot be obtained the use of a starter of high quality, careful pasteurization, and thorough washing of the curd seem to be the next most efficient steps to control feed flavors. Storage should be only for short periods, at 32° to 35° F., in clean containers, and in clean refrigerators free of odors.

Mouldy flavors: Usually due to the growth of mould, of which there are many types; may be controlled by reducing the amount of surface exposed to the air, shorter storage periods, or by packing the cheese under vacuum.

C.J.B.

Common Defects in the Body of Cottage Cheese. W. V. Price, Univ. of Wisconsin, Madison, Wis. The Milk Dealer, *24*, 7, p. 34, April, 1935.

The condition known as *hard* and *dry* is caused (1) by improper cutting of the curd and (2) by lack of control of the firming process. Curd must be cut into pieces of uniform size. Curd knives and careful stirring are necessary to produce minimum breakage. Temperature of heating must be controlled to suit the size of the curd particles. Checking the firmness of the curd by thoroughly chilling in cold water is a helpful method to avoid overworking.

The condition known as *tough* and *rubbery* type cheese is caused by too much rennet or the development of too little acid. Carefully measure the rennet and determine time for cutting the curd by the acid test.

The whey used for determining the acidity should be pipetted from several inches below the surface of the curd and then centrifuged in order to obtain a clear whey for measuring the titratable acidity.

The defect known as *soft* and *mushy* may be caused by (1) improper pasteurization, (2) insufficient heating of the curd, (3) the washing treatment, (4) excess acidity, or (5) the creaming of the curd.

Pasteurization, whether accomplished by the flash method at 160° to 165° or by holding 30 minutes at 143° to 145° F., should be carefully controlled. The time of dipping should be determined by the size and firmness of the

curd particles. The cubes of curd should be plump and firm and should have no soft centers. The draining process should not be hurried and excessive washing avoided. Acidity of whey should not exceed 0.55 per cent and should be controlled by time of cutting the curd, amount of starter used, and by careful use of carefully checked thermometers. The percentage of butterfat in the cream used for creaming should depend upon the moisture content of the curd.

Low yields of cheese are caused by (1) high acidity, (2) excessive amounts of rennet, and (3) careless handling of the curd. These may be avoided by carefully controlling the acidity, measuring the amount of rennet used and careful handling of the curd.

A conservative estimate of yield of cottage cheese can be obtained by dividing the casein content of the milk by the factor 0.16. The casein content can be calculated fairly accurately by the formula: Per cent casein = 2.1 plus (fat in milk – 3) 0.4. C.J.B.

A Gas Defect of Cream Cheese. W. J. Corbett, W. J. Frazier and W. V. Price, Univ. of Wisconsin, Madison, Wis. The Milk Dealer, *24*, 3, p. 38, Dec., 1935.

A report is made of a study of a gas defect found in cream cheese, especially cream cheese flavored with pimientos, sweetened crushed pineapple, or sweet-pickle relish. This gas defect was found to be due to yeasts. C.J.B.

ICE CREAM

A New Bacterial Species Isolated from Strawberries. Helen F. Smart, U. S. Dept. of Agr., Washington, D. C. Jour. Agr. Res., *51*, 4, p. 363, 1935.

In a microbiological investigation of frozen-pack fruits the author reports a new bacterial species for which the name *Achromobacter delmarvae* is proposed. The organism was isolated from fresh strawberries found in four localities in Delaware, Maryland and Virginia. It was the predominating organism in the berries studied whether or not they were washed before sampling, and it occurred principally on the outside of the fruit. So far as is known the organism has no effects on the texture, flavor, appearance or healthfulness of fresh or frozen strawberries.

The organism is a nonmotile, Gram-negative nonsporeforming short rod; agar colonies are round, raised, glistening, smooth, entire margin, amorphous. It grows best at 26 to 31° C. (78.8 to 87.8° .F). In milk it forms acid curd in 12 to 14 days; color of milk becomes chocolate brown. L.M.T.

Freezing Fresh Milk. Is this Method of Preserving a Solution to the Surplus Problem? RALPH V. GRAYSON, Polar Products, Inc., Atlanta, Ga. The Milk Dealer, *24*, 7, p. 30, April, 1935.

The author suggests freezing fresh milk as a method of overcoming the surplus problem. A high-grade milk produced in strictly sanitary dairies was furnished in earthen containers and pasteurized at 145° F. for 30 minutes, homogenized, filled into the receiving reservoir of the Grayson de-aerating-freezing unit, where a vacuum of 28.80 inches was maintained for 20 minutes, after which it was frozen to a slush in four and one-half minutes, still under vacuum. From the freezer the milk slush was filled into one-gallon stone jugs of thermic type and sealed under 15 inches vacuum. The jugs were placed in the Grayson-Foster freezing unit, which freezes at – 45° F., and frozen hard in one hour and 55 minutes. The product was then stored at 0° F.

This product was examined at intervals of 30 days and the quality of the product was found to be excellent and comparison with fresh milk at each interval indicated very little, if any, change in the product.

It was found by Dr. Leah Ascham of the Department of Home Economics, Georgia Experiment Station, that milk frozen by the quick-frozen method and tested after being stored for 4 months and two years, respectively, showed no significant lowering of vitamin A or vitamin G content over that found in fresh milk from the same source.

Committee comments: No data were presented on the cost of preserving milk by freezing. C.J.B.

The Continuous Freezer. A Symposium. Proc. 35th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs., *2*, p. 85, Oct., 1935. A. **Its Effect on the Texture of Ice Cream.** W. H. E. REID, Dairy Dept., Univ. of Mo., Columbia, Mo.

Ice cream mixtures ranging in butter fat from 8 to 18 per cent were frozen in the continuous freezer and hardened at a temperature of – 15° to – 20° F. with forced air circulation. As the butterfat content was increased in increments of 2 per cent the texture changed from a slightly coarse to a smooth texture until 14 per cent fat was reached. From 14 to 18 per cent fat an increasing tendency towards a salvy texture resulted. Mixes varying in serum solids from 8 to 15 per cent were frozen. Ice cream with 8 per cent serum solids was grainy in texture; with 10 per cent serum solids the grainy texture was entirely absent, above 10 per cent serum solids the ice creams were too close in texture and inclined to be brittle. Variations in sugar from 12 to 20 per cent showed very little difference in texture at 12 and 14 per cent levels. Sugar percentages of 16, 18 and 20 produced ice creams which were very close in texture and slightly crumbly in body. As the

gelatin content was increased from 0 to 0.3 per cent in increments of 0.1 per cent the ice creams became smooth and closer in texture. A gelatin content of 0.5 per cent produced ice cream which was too smooth and close in texture.

Ability to control the overrun accurately with the continuous freezer aids in the manufacture of a smooth textured, uniform ice cream. The small crystal structure in the ice cream is conducive to a more pronounced flavor. Some manufacturers have decreased their flavoring costs by changing to the continuous freezer.

The comparison of ice creams frozen on three different types of freezers revealed that the continuous freezer produces smaller ice crystals than other types of freezers. This is attributed to the high speed of the mutator in the continuous freezer, the rapidity of freezing, and the low drawing temperature of the ice cream. Microphotographs which accompanied the article reveal the variations in crystal structure observed in the study.

B. **Its Use in Packaging Ice Cream.** ALLYN B. WICKS, H. P. HOOD AND SONS, Inc., Cambridge, Mass.

During the development and early use of the continuous freezer, this company followed the viewpoint that the continuous freezer would not be accepted unless it produced an ice cream of equal or better quality than that made in the batch freezer and that it be applicable to 100 per cent of the product made. The seemingly biggest problem was the filling of packages up to one quart in size. A set of extensions have been constructed for the continuous freezers to suit the shape and size of the varied style and sizes of containers used. By means of a clamping arrangement these extensions are readily interchangeable. The changes are made with sufficient ease that production is not slackened when changing from one sized package to another. Loss of time and product in changing flavors is kept at a minimum by synchronization of all freezer and pump speeds and by operator control. The time loss with batch freezers, hopper, and filling machine arrangement with attendant wash out exceeded that for the continuous freezers.

The following figures show the gallons of packaged ice cream manufactured per man hour. The figures are based on actual plant operations for a representative week in 1934 with a batch, hopper, machine-fill method versus a similar week in 1935 with continuous freezers and direct filling.

TYPE PACKAGE	1934	1935	GAIN
One-half pints	21.4	22.3	4.2 per cent
Pints	26.6	40.7	53.0 per cent
Fifths	34.8	39.7	14.0 per cent
Quarts	.....	38.1	

The capacity per machine hour is also greater with the continuous freezer than with the batch freezer. With batch freezers, in 1934 a capacity of 90 gallons per machine hour was realized; in 1935 with the continuous freezer, operation at a capacity of 130 gallons per man hour was attained.

Another type of packaging done successfully by the use of two continuous freezers is the direct filling of center mould packages. Center moulds such as sultana rolls, nut rolls, or ice cream with a core of chocolate fudge syrup, fruit, or other syrups, can be made in this manner. The direct filling of souffle cups, with a space at the top for garnishing, has been done with the continuous freezer. Thirty inch slabs of ice cream have been cartoned, then stripped of the carton after hardening, for use in slicing machines.

C. **Comparative Operating Costs.** H. F. DePew. Luick Ice Cream Co., Milwaukee, Wisconsin.

Comparative operating costs vary with the size and number of freezers, number of operators, condition of freezers, temperature of refrigerant and the use of conveyors. The efficiency of operation depends largely on the type of installation used. However, the continuous freezer is more efficient for packaging ice cream than batch freezers; as for freezing bulk the type of installation is the deciding factor.

Comparative operating costs over a ten weeks' period in four plants on batch freezers as compared with four plants using continuous freezers follow. The number of units frozen per labor hour were:

Continuous freezers	74.1 units
Batch freezers	57.6 "

The average labor cost of freezing were:

Continuous freezers	$.0139 per gal.
Batch freezers	.0202 " "

The maintenance costs in one plant averaged $25.00 a year per batch freezer and $100.00 a year for a continuous freezer. In another plant repairs (excluding labor cost) averaged $27.08 per freezer with continuous freezers for a period of six months. The lower load per gallon of ice cream frozen appears larger with batch than with continuous freezers.

The general conclusion is drawn that comparative operating costs are hard to figure on an equitable basis because of the many variable conditions which exist. However, the difference in operating costs under the two systems is not great enough to be a major factor in determining the type of freezer which should be purchased. M.J.M.

The New Era in Ice Cream Sanitation. F. W. Fabian, Dept. of Bacteriology and Hygiene, Michigan State College, East Lansing, Mich.

Proc. 35th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs., *2*, p. 56, Oct., 1935.

There is evidence of a trend towards more adequate state and city sanitary regulations governing ice cream production. In 1929 only two states and one province required pasteurization of the mix. Now 26 states and provinces (6 other states require the use of "Grade A" or pasteurized milk products) require pasteurization of mix or milk products used. In 1927 one state had a maximum bacterial count established for ice cream; now 12 states have such standards.

A regulation requiring that ice cream be frozen at the place of pasteurization is recommended. It is suggested that another requirement be that the mix must flow in a closed pipe line from the pasteurizer to the freezer. The Michigan law requires that the pasteurization time be dated and holding time before freezing be limited to seven days. A time limit of no more than 24 to 48 hours is ample but freezing within 2 to 4 hours after pasteurization is recommended as the ideal. Dating of ice cream at the time of freezing is recommended.

The author proposes that ice cream be graded. Grade A ice cream should be made from fresh milk, cream, and condensed milk and should meet certain chemical and bacteriological standards. Grade B ice cream should be that made from milk products such as powdered milk, frozen cream, condensed milk (older than 24 hours), butter, etc. Both Grades A and B should meet the same sanitary and chemical standards. A third Grade, Grade C ice cream is proposed. This would include ice creams of lower butter fat content than the standard for Grades A and B.

The suggestion is made that schools for the instruction of workers in dairy plants in the fundamentals of sanitation be maintained. M.J.M.

Another Year's Experience with Single Service Cans. A Symposium. Proc. 35th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs., *2*, p. 70, Oct., 1935.

1. Ridgway Kennedy, Jr. Abbotts Dairies, Inc., Philadelphia, Pa.

Paper cans were found to be more satisfactory than metal cans because delivery trucks are cleaner (since no dirty cans need be returned), quieter, and lighter by about 1000 pounds per load. The production plant operates satisfactorily on paper cans because the necessity for can washing and rehandling of metal cans is eliminated. Operating expenses are lowered by the use of paper cans.

Paper cans were found to be less satisfactory for dipping because of a weaker side wall than metal cans. The problem for disposal of the paper cans is also annoying to the retailer.

The cost of paper cans has averaged slightly more than metal cans. However the plant overhead is decreased and trucking costs are lowered by the use of paper cans. These savings more than offset the higher cost of the paper cans.

2. J. H. LANDESS. Fortunes, Inc., Memphis, Tenn.

The cost of using metal cans and jackets, including express on returned cans, can washing, labor, water, steam, and depreciation charges was $.0679 per gallon of ice cream. The cost of paper cans, including shippers, tape, dry ice, was $.0916 per gallon. However average express rates with metal cans was 17 cents per gallon of ice cream while with paper cans the average was 9 cents per gallon. Adding the express rate to each of the initial cost figures, a difference of $.0563 per gallon in shipping costs exists in favor of the paper cans. The use of paper cans instead of metal cans for public truck or express deliveries is cheaper, especially when the distance exceeds 50 miles.

Paper cans have been improved very little since first appearing on the market. Trouble was experienced with the tops and bottoms pulling loose. In dipping, the dipper catches on the metal stitching on the side of the can. Trouble was experienced with the ice cream getting soft near the center of the cans and shrinking during shipment.

3. J. MORRISSEY. De Coursey Creamery Co., Kansas City, Kansas.

This company adopted the single service container for shipping ice cream. The paper can reduced shipping costs due to the light weight of the can. Shrinkage of ice cream in the can on long distance shipments has been a troublesome factor.

Single service cans have many advantages for city delivery. They are cleaner, easier to handle, and eliminate the necessity of washing returned cans.

4. R. J. QUIRIE. Silverwood's Ltd., London, Ontario, Canada.

This writer has used the heavy metal can, the light weight metal can and the paper cans. In changing the buyer of ice cream over from the heavy metal can to the paper can, the light weight single service metal can has bridged the gap between the two, thus making the transition easier.

The dry ice and light weight can cannot compete with the jacket and heavy can within an area of about 100 miles; here the jacket without dry ice is more satisfactory. For longer shipments the use of the single service can is cheaper because there is no empty can to return and shipments are lighter. The single service cans also eliminate the cost of retinning cans.

5. S. SCISM. DeLuxe Ice Cream Co., St. Louis, Mo.

Paper cans were first used by this company for express shipments and now are used for city delivery as well. Many of the dealers in St. Louis are buying the cans cooperatively to keep down costs.

The use of paper cans makes possible more cleanly conditions in delivery as well as in the production of ice cream. Another advantage of the paper can is that it can be dated conveniently so that the age of any can of ice cream is known.

6. CARL KOERVER. Pioneer Ice Cream Brands, Inc., Brooklyn, N. Y.

The primary purpose of changing to paper cans was in the interests of sanitation and better service to dealers. However, the company has experienced savings in all phases of the business through the use of paper cans. Loading out trucks is more rapid and unloading returned trucks is simple because there are no returned cans. Since the paper cans are light, transferring ice cream to branch plants has been made easier than when metal cans were used.

The appearance of the manufacturing plant, loading platform and trucks has shown sufficient improvement, due to the use of paper cans, to justify their use even though no saving of money should result from the change.

M.J.M.

Power, Light, Heat, Refrigeration, Water—Their Costs and Conservation. A. H. BAYER, General Ice Cream Corp., Schenectady, N. Y. Proc. 35th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs., *2*, p. 64, Oct., 1935.

The importance of economy in plant operation is stressed by the author who gives the following cost figures as existing in plants with which he is familiar: The cost of the power and refrigeration for mixing varies from $.0097 to $.0358 per gallon, the average being $.0193. For freezing a gallon of ice cream power and refrigeration costs average $.0093 with a range of $.002 to $.0382; for hardening of ice cream costs varied from $.0126 to $.0774 per gallon, the average being $.0350. The total power and refrigeration costs per gallon of ice cream for mixing, freezing and hardening averaged $.0573 per gallon with variations from $.0339 to $.1001. Obviously, if one plant is doing a complete job for power and refrigeration at a cost of $.0339 per gallon and another plant at a cost of .10 per gallon, there must be a lesson in economy to be learned in the plant with low costs.

The author tabulates about 80 different factors which should be considered in a cost study of power, heat and refrigeration. In one plant careful consideration of operating costs resulted in a saving of $10,000 per year. In another plant changes were made so that heat from exhaust steam could be utilized. Saving in coal for the first year paid for the change.

M.J.M.

What is a Practical Bacterial Standard? R. C. FISHER, R. F. Worden and Sons, Inc., Waterbury, Conn. Proc. 35th Ann. Conv. Intern. Assoc. Ice Cream Mfgrs., *2*, p. 60, Oct., 1935.

The author stresses the fact that bacteria counts are only estimates and have value only in that they are measuring sticks to sanitation of the product and plant. No conclusion can be drawn from one determination. Arithmetical averages of bacterial counts are likely to result in injustices. Logarithmic averages of not less than three consecutive counts are essential in order to draw fair conclusions.

Bacterial standards should be in the form of regulations rather than actual acts of legislation. Included in the regulations should be additional requirements such as (1) The standard procedure of the A.P.H.A. be strictly followed. (2) Laboratory technicians and those doing the field sampling should be fully qualified for the work. (3) Logarithmic averages of three counts taken within two weeks should be the basis of counts. (4) Samples should be collected only from unbroken packages.

Essentials in obtaining satisfactory bacteria counts are (a) pasteurization of the entire mix at 155° F. for 30 minutes; (b) thorough cleaning and sterilizing of all equipment; (c) constant checking of flavors, syrups, fruits and colors; (d) line run test to determine source of contamination when high counts occur.

The regulation in Connecticut of a maximum count of 100,000 bacteria by the standard plate method is not working undue hardship on the ice cream industry. M.J.M.

MILK

Survey of Temperature Requirements of Milk in Transit. The Milk Dealer, *24*, 6, p. 42, March, 1935.

A survey made by the Milk Dealer of cooling requirements reveals that most states appreciate the importance of cooling. The survey shows that those states having regulations have cooling requirements ranging from 50° to 70° F., the most frequent state requirement being 60° F. The municipal requirements for cooling are lower as a rule than the state requirements. The most frequent requirement for Grade A milk is 50° F. but requirements range as high as 55° F. Grade B milk is required to be cooled to 60° F. by the municipalities covered in the survey. Some municipalities make exceptions for morning milk that is to be pasteurized, or for milk to be pasteurized within 2 hours after milking. The requirements for the latter range from no cooling to cooling to 55° F., the most common requirement being 70° F. C.J.B.

Some Recommended Methods for Producing Cultured Buttermilk. David A. Meyer and Luther Mindling. The Milk Dealer, *24*, 6, p. 62, March, 1935.

Milk, skimmilk, or reconstituted milk may be used for making cultured buttermilk. It should be pasteurized at 180° to 190° F. for one hour. After holding, cool to 68° in summer and 72° in winter and add one to three per cent good clean-flavored culture. The acidity should develop to .73 to .85 per cent, depending upon the method of handling and the type desired. When proper acidity has been developed, add from one-half to two pounds (as the trade demands) of salt per 100 gallons of buttermilk. Cool to 40° to 45° F. and bottle.

Flake buttermilk should contain from one-half to one per cent butterfat to give correct amount of flakes. Color should be added and the buttermilk churned at 60° to 72° until the flakes are about 1/32 to 1/16 inch in diameter. Not more than from 15 to 20 minutes of churning should be required. Churning a high-test buttermilk and then adding the flakes to a larger vat of buttermilk at 45° is also practiced. Other methods of making flake buttermilk are by spraying highly colored melted butter (about 1 ounce of color to one pound of butter) into buttermilk as another man stirs it with a stirring rod, or by adding highly colored butter to milk at 40° F. and vigorously whipping the milk.

Wheying off of bottled buttermilk may be due to too low pasteurizing temperatures; high setting temperatures causing the acidity to develop too rapidly; an acidity below 0.70 per cent; or storage at too high a temperature. More buttermilk, however, is spoiled by incorporation of air than by any other mechanical defect. Therefore care should be exercised not to unduly agitate the buttermilk by pumping, cooling, etc.

Too thick or too thin a body may be due to the type of culture, too high or too low acidity, too high pasteurizing temperature, insufficient or too much agitation, or excessive or not enough milk-solids-not-fat. The optimum body seems to be between .75 and .80 per cent acidity. The percentage of milk-solids-not-fat should be about 8.5.

Lumpiness may be caused by too high acidity of the milk, too high setting temperature, or insufficient agitation.

Cultures for buttermilk are a combination of *Streptococcus lactis* and *Streptococcus citrovorus*. Off-flavored cultures are caused by the incorrect balance between these two organisms or by contamination. Milk used for cultures should be the best quality obtainable. It should be pasteurized in the containers in which it is made at 190°F. for one hour, cooled to 68°, inoculated with good clean-flavored mother culture, incubated until well set (acidity about .85 per cent), and then cooled to 40° until used. Cultures not used daily may be transferred once or twice a week, or they may be frozen and held for several months.

Careful control of the development of acidity so that the *S. lactis* and *S. citrovorus* organisms grow in proper balance insures a good-flavored prod-

uct. With proper precautions as to sterile equipment, a yeasty or malty flavor should never be encountered. Cultures which have developed bad or off flavors can sometimes be corrected by careful propagation, but the better practice usually is to discard such cultures. C.J.B.

The Manufacture of Popular European Special Milks. J. M. Rosell, Univ. of Montreal, Oka, Quebec Canada. The Milk Dealer, *24*, 7, p. 41, April, 1935.

The author calls attention to the large number of cultured milks which are being sold in Europe. Special attention is called to the large quantity of Yoghourt sold daily. Yoghourt results from the combined action of *Streptococcus thermophilus, Bacterium bulgaricum*, and *Plocamobacterium yoghourtii* on ordinary or one-third evaporated whole milk. Yoghourt appears to be more digestible than acidophilus, of at least equal therapeutic value, and commands wider use because of its pleasant taste. Its preparation is neither a difficult nor a lengthy process. C.J.B.

Stimulate Your Summer Sales with Orangeade. E. W. Thompson, Los Angeles, California. The Milk Dealer, *24*, 8, p. 36, May, 1935.

The author states that facts which present themselves point to the conclusion that the sale and distribution of orangeade by milk dealers is profitable and satisfactory. C.J.B.

Milk and Its Mates. G. H. Rothe, Southern Division, California Dairy Council. The Milk Dealer, *24*, 9, p. 33, June, 1935.

The author calls attention to the amount of advertising milk receives by being teamed with other products such as flavoring extracts, soups, gas, and life insurance. The conclusion is drawn that there is more advertising for milk paid by "team mates" than is placed by the milk industry itself. The public is beginning to view milk through the eyes of other industries, and unless the milk industry does more advertising of its own, time may come when the public generally will regard milk as a secondary rather than primary substance. C.J.B.

Art of Whipping Cream Acquires a Scientific Finesse. New Device Assures Consumer 100 Per Cent Whipping Success. G. Frederick Smith and C. A. Getz, Univ. of Illinois, Urbana, Ill. The Milk Dealer, *24*, 9, p. 36, June, 1935.

A new patented device and process for making and dispensing whipped cream. The device is similar to the familiar soda siphon bottle, but is unbreakable and has a removable dispensing nozzle. The dispensing nozzle is furnished to the consumer. The bottle, of 1 pint size, is delivered to the

consumer containing one-half pint of cream and charged with nitrous oxide gas at 75 pounds pressure per square inch. The charged bottle is kept in the ice box and by use of the dispensing nozzle the consumer can have whipped cream on a moment's notice. The device successfully whips fresh cream of any butterfat content from 20 to 40 per cent and the overrun may reach as high as 450 per cent. C.J.B.

Nation-Wide Survey Reveals Trend in Sale of Chocolate Milk. The Milk Dealer, *24*, 10, p. 38, July, 1935.

This survey shows that chocolate milk is recognized as an important sales item for the milk dealer. Of those reporting, 94 per cent of the mid-western dealers, 79 per cent of the southern dealers, 70 per cent of the eastern dealers, and 65 per cent of the far-western dealers sold chocolate milk. The majority of those contacted through the survey advised that they enjoyed a profit on chocolate milk equal to or exceeding that on milk sales. C.J.B.

What Are the Sales Possibilities of Chocolate Milk? The Milk Dealer, *24*, 10, p. 40, July, 1935.

Experience of dairies shows that some 80 per cent of chocolate milk volume is plus-volume of milk and not replacement volume. Main outlets for chocolate milk were found to be, 1st, retail routes and stores; 2nd, schools; 3rd, restaurants; 4th, factories; 5th, hotels and filling stations; and, 6th, stands. C.J.B.

Further Facts on the National Trend in Chocolate Milk Sales. The Milk Dealer, *24*, 11, p. 52, August, 1935.

Milk dealers favored bottle sizes for distribution of chocolate milk in various sections as follows: East: Pints 4.5 per cent, quarts 29 per cent, ½ pints 66.5 per cent; Middle West: Pints 26 per cent, quarts 37 per cent, ½ pints 37 per cent; Far West: Pints 22 per cent, quarts 61.5 per cent, ½ pints 16.5 per cent; South: Pints 8 per cent, quarts 8 per cent, ½ pints 84 per cent.

The sales in quart bottles were made for the most part on the retail routes. Some 72 per cent of the milk dealers who replied to the questionnaire and who centered their sales efforts on quart sales, reported an increase in chocolate milk sales over last year. Only 48 per cent of the dealers selling principally half-pints reported a similar increase.

The survey showed that the retail route customer is the most favorable outlet for chocolate milk. C.J.B.

Scientific Feeding, Stable Labor Control Reduce Horse Route Costs. REGIS LAFEBURE, Horse and Mule Association of America. The Milk Dealer, *25*, 4, p. 40, January, 1936.

The association's figures indicate that dairies with very large branches find it most profitable to use single horses on routes 20 miles in length, electric trucks on routes 20 to 30 miles in length, and gasoline trucks beyond the electric-truck zone. On the other hand, dairies with small branches find it more economical and efficient to use horses on routes up to 20 miles and gasoline trucks outside the horse zone. C.J.B.

Straining Milk on the Farm. A. C. DAHLBERG, N. Y. State Agric. Exp. Sta., Geneva, N. Y. N. Y. Agric. Exp. Sta. Cir. *155*, Dec., 1935.

Either single service cotton pads or filter cloths can be used for straining milk. Filter cloths are usually comparable to a good grade of outing flannel. Generally cotton pads remove more dirt than filter cloths but have less capacity.

The cotton pads may have a protecting gauze on one or both sides. A metal support in the bottom of the strainer is necessary to prevent tearing and a perforated disc is usually placed above the cotton to break the force of the falling milk so as to prevent channeling of the cotton fiber. No supporting grid is necessary for cloth. The cloth can be supported by an inside perforated disc or by an outside clamp.

It is important to strain milk while it is still warm. A strainer pad will handle three times as much milk at 90° F. as it will at 80° F. Hand milking usually produces warmer milk than machine milking. P.H.T.

Methods of Inspecting Milk at the Receiving Platform. J. L. HILEMAN, Lab. Division, Dairymen's League, Syracuse, N. Y. The Milk Dealer, *25*, 2, p. 30, Nov., 1935.

A description of the Dairymen's League system of inspecting milk at the receiving platform is given based upon odor of the milk at the platform and direct microscopic examination. C.J.B.

Cost of Distributing Milk in Los Angeles. JOHN MARSHALL, JR., Div. of Markets, State Dept. of Agr., California Pacific Dairy Rev., *38*, 9, p. 16, Sept., 1934.

This study was financed by a trust fund, established by the Los Angeles Milk Industry Board with the State Department of Agriculture, Sacramento, California. This money was contributed equally by the producers and distributors of the sales area in accordance with the United States Department of Agriculture, License No. 17, for milk, Los Angeles, which became effective November 20, 1933.

The twenty-one distributors from whom costs were obtained handled approximately 75 per cent of all the pasteurized milk sold in the Los Angeles sales area during the year 1933.

In examining the data it was noted that the cost of distribution, plus the cost of the raw product, showed that the majority of the business of these concerns was being handled at a loss under present conditions. J.C.P.

First Truly Silent Horse Wagon. (No author given). Food Industries, *6*, 9, p. 412, Sept., 1934.

Illustrations are presented showing the pneumatic tired milk wagons which were placed on the streets of New York City on August 28. The horses are also "silenced" by rubber covered shoes, which are made in the open-face form common to the familiar steel shoes.

Charts are presented showing comparative noises produced by the ordinary and converted milk wagons, and also the weight or relative pound pull required to start the two types of wagons from rest on two different kinds of pavement. J.C.P.

Dairy Refrigeration on Rural Electric Lines. E. C. Easter and M. L. Nichols, Alabama Polytechnic Institute, Auburn, Alabama. Alabama Exp. Sta. Bul. *241*, April, 1934.

From this study the authors reach the following conclusions:

Retail dairies should have a refrigerating plant with a minimum of 15 pounds of "ice melting capacity" per 24 hours operation for each gallon of milk produced per day. Dairies producing milk for the wholesale market should have 10 pounds of "ice melting capacity" per 24 hours operation for each gallon of milk produced per day. By using well water in one section of the surface cooler the minimum capacity of refrigeration can be reduced 2.5 pounds. The refrigerator should not need to operate more than 18 out of 24 hours.

In terms of kilowatt-hours, retail dairies will require about 7.6 kilowatt-hours per month for each gallon of milk cooled per day, while wholesale dairies will require 4.6 kilowatt-hours per month for each gallon of milk cooled per day. P.H.T.

Soft Curd Milk Studies. M. H. Berry, Univ. of Maryland, College Park, Maryland. Milk Plant Mo., *23*, 10 and 11, 1934.

It was found in this investigation that holding milk cold for one week did not significantly change the curd tension provided that the acidity did not increase.

The curd tension of milk from individual cows did not change noticeably between milkings over a short period of time. Noticeable exceptions to this

general observation were recorded. Colostrum forms a very hard curd. This softens materially as the milk becomes suitable for human consumption.

Freezing and thawing milk tended to increase its curd tension. Ordinary pasteurization at 143° F. for 30 minutes did not materially change curd hardness. Temperatures of 180° F. or above for 15 to 30 minutes reduced the curd hardness. Bringing milk to a temperature of boiling noticeably affected the hardness of the curds.

Hard curd milk could be converted into a soft curd product by homogenizing at 3000 to 5000 pounds. The author homogenized the milk at 120° F.

Experiments with rats failed to show that soft curd milk had an advantage over hard curd milk in producing normal development. J.C.M.

New Apparatus for Determining the Curd Character of Milk. A. P. Cole, Michigan State College, East Lansing, Mich. Milk Plant Monthly, *24*, 1, p. 24, Jan., 1935.

The author describes a new curd tension apparatus by the use of which it was possible to secure results which did not exceed six per cent in variation as compared to about 17 per cent by other methods. The speed of the knife cutting through the coagulated milk is made uniform through hydraulic means. Illustrations are given.

The apparatus consists of a beaker, curd knife, metal plunger, and the measuring device proper. G.M.T.

Limitations of the Methylene Blue Test in Grading Milk. E. G. Hastings, Univ. of Wisconsin, Madison, Wis. The Milk Dealer, *24*, 7, p. 72, April, 1935.

The author explains the factors affecting the reduction of methylene blue and concludes: "From our present knowledge it is believed that when the reduction time is in excess of eight hours the methylene blue test will not give, with sufficient accuracy for control work, the bacterial content of the milk examined." C.J.B.

Correlation of the Viscosities of Protein Solutions with Their Ability to Crystallize. David B. Hand, Dept. of Physiol. and Biochem., Cornell Univ., Ithaca, N. Y. J. Gen. Physiol., *18*, p. 847, July, 1935.

Published values for the viscosity of different protein solutions at various concentrations were reduced to values at the same protein concentration, by means of the empirical formula of Kunitz (J. Gen. Physiol. *9:* 717 and *10:* 811). It was found that 1 per cent of crystallizable proteins have relative viscosities less than 1.060 while amorphous proteins have vis-

cosities greater than 1.085. Data are given for ten proteins. Casein is exceeded in viscosity only by gelatine. The author believes that variation of viscosity with pH and salt concentration is not sufficient to alter classification of proteins into crystallizable and amorphous proteins on the basis of viscosity. B.L.H.

Presence of Yeasts in Fruit Juices that are Sold for Beverages. J. M. BRANNON, Univ. of Ill., Urbana, Ill., and R. J. POLLITT, Beatrice Dairy, Danville, Ill. The Milk Dealer, *25*, 2, p. 35, Nov., 1935.

The authors call attention to the fact that while fruit juices (such as orange juice) contain very few bacteria, they do contain yeast, thereby necessitating that care be exercised in the handling and disposition of such fluid foods. C.J.B.

Weigh Can vs. Single Can Samples for Bacterial Analysis. A. H. ROBERTSON, N. Y. State Dept. Agric. and Markets, Albany, N. Y. The Milk Dealer, *24*, 3, p. 56, Dec., 1935.

A brief discussion of the methods of procuring milk samples for bacterial analysis is given. It is concluded that since the weigh can sample is more truly representative it is fairer to all concerned. C.J.B.

Increasing Solids-Not-Fat. W. M. REGAN, Prof. of Animal Husbandry, Univ. of California, Davis, California. Pacific Dairy Rev., *38*, 8, p. 14, August, 1934.

Experiments were conducted at the California Experiment Station which showed that neither the turning of high producing cows to abundant alfalfa pasture nor the feeding of as much as 40 pounds of wet brewers' grains daily affected in the slightest the percentage of solids-not-fat in the milk which they produced.

Another experiment is being conducted to study the effect of feeding concentrates only. Cows are now in their second milking period that have never had any roughage during their lives. At the height of lactation some of these cows ate 25 pounds of concentrates daily. In all cases, their milk was normal for the breed in solids-not-fat.

Some dairymen and regulatory officials believe that the percentage of solids-not-fat in the milk can be influenced by the kind of food furnished the dairy cow, but it has been shown to be due to other factors—the individuality of the cow, her period of lactation, or to the season of the year.

It is possible for any dairyman to raise the average solids-not-fat content of the milk from his herd through one or all of three processes, as follows—he may add high solids cows, either of the same breed that he has already, or of a new breed; he may eliminate from his herd the cows

that are extremely low; and he may use herd sires selected from families noted for high solids-not-fat.

Committee comments: Families of cows within a given breed that are known to give high-solids milk are rare. J.C.P.

Detection of Mastitis Through Examination of Milk at the Dairy Plant. E. G. HASTINGS, Dept. of Agr. Bact., Univ. of Wisconsin, Madison, Wisconsin. Milk Dealer, *23*, 10, p. 46, July, 1934.

This paper, presented at the 1934 University of Wisconsin Dairy Manufacturers Short Course, discusses very briefly the laboratory methods which may be used to detect mastitis in milk. They are; examination of strainers for flocculent material, analysis of milk for chlorine content, microscopic examination, the catalase test, and examination of cultures of milk on various kinds of agar.

Tests should be made on the milk from individual cows and are of the greatest value when applied to the first few streams of milk drawn from each quarter of the udder. Young animals are likely to be free from udder infection; the older animals are likely to be infected.

There is no authentic data on the importance of the disease as a factor in reducing the production of the individual animal. It is not likely that milk from inflamed udders will produce sickness in man. The organism causing septic sore throat in man however, may produce a type of inflammation of the udder, and is of great sanitary significance.

While mastitis may not present a sanitary problem at present, it does present a problem to which the milk producers and distributors should give serious consideration. J.C.P.

A Study of the Effect of Removing Foremilk on the Fat Content of the Remainder of the Milking. H. E. ROSS AND HELMUTH WINTHER, Dept. of Dairy Industry, Cornell Univ., Ithaca, N. Y. Cornell Univ. Exp. Sta. Bul. *589*, March, 1934.

This study was prompted by the demand of the metropolitan milk market that grade A milk contain not less than 3.5 per cent milkfat. Milk from 45 cows of the University herd was examined, representing six breeds. The cows varied in lactation period from one to twelve months. The number of streams of milk removed from different quarters of the udder varied, being 5, 10, 15 and in some cases 20. The Babcock test was used in determining the percentage of butterfat. The removal of foremilk from each quarter of the udder increased the fat content of the remainder of the milking, but it was necessary to remove a considerable portion of the foremilk to obtain an appreciable increase in the remainder.

In the case of the Holstein, removing 20 streams of the foremilk from each quarter raised the fat content of the remaining milk 0.17 per cent. The 20 streams represented almost 10.5 per cent of the entire milking.

P.H.T.

Commercial Production and Scientific Value of Soft Curd Milk Produced by Base Exchange Treatment. H. E. Otting and J. J. Quilligan, M. and R. Dietetic Laboratories, Inc. Milk Dealer, *23*, 11, p. 36, August, 1934.

This paper was presented at the annual meeting at the American Dairy Science Association, Ithaca, New York, June 26 to 28, 1934. The base exchange treatment, reported by Otting and others in 1933, allows a down-flow of milk to come into contact with a bed of Zeolite which rests on 50 mesh stainless steel cloth.

The following procedure is given:

"Raw milk of any degree of curd tension is placed in a vat acidified to 0.3 per cent as lactic with a 2N citric acid solution, preferably at a temperature below 50° F. to prevent curdling. The milk is then heated to 64° F. and, after removing air from the bed of Zeolite by up-flow treatment, the milk is allowed to pass down-flow through the Zeolite into another vat. At the present time 700 gallons of milk is passed through seven cubic feet of Zeolite in 1¼ hours, the treated milk having an acidity of 0.15 per cent and the hydrogen ion concentration of 6.50. For the period of a year the bacterial counts have averaged about 5000 cc. as measured by the standard plate count."

This treatment produces milk of zero curd tension, as compared to the soft curd standard of 20 to 30 grams set by Hill at the Utah Agricultural Experiment Station. A modified Hill test was used to determine curd tension. Although there is a reduction in calcium and phosphorus, metabolism tests have shown that they are better utilized from base exchange milk, probably due to the presence of a double amount of ultrafilterable calcium as compared with regular milk. There is also a slight adjustment of the ash, its alkalinity increasing in base exchange milk.

This process produces milk differing very little in taste, appearance, and other qualities of regular milk. The cream line is practically the same as in pasteurized milk, and if disturbed after once formed, returns more quickly and thoroughly than in regular milk. Bacteria count averages several thousand less in pasteurized base exchange milk as compared to the same milk without treatment which may be due to a filtering out of bacteria when the milk passes through the Zeolite, or to a lowering of the heat resistance through a rearrangement of salts.

The authors predict, after noting the comments and observations of users and physicians, that base exchange milk has good market possibilities.

J.C.P.

Elimination of *Brucella abortus* with the Milk of "Carrier" Cows. REDVERS THOMPSON, McGill University, Quebec, Canada. J. Inf. Diseases, *55*, 1, p. 7, July-Aug., 1934.

Since the attempts to cure or immunize animals against infectious abortion have repeatedly failed, the disease must be considered in the same category as tuberculosis. If the organism, *Brucella abortus*, is pathogenic for man, the mode and extent of its elimination from its host are important questions for public health. Previous investigations have established that the organisms may be eliminated in the milk from infected animals. The present investigation deals with the isolation of *Brucella abortus* from "carrier" cows whose history gives no outward manifestations of infectious abortion and whose production of milk places them in the category of "high producers." From the dairyman's point of view he would have regarded these animals as healthy, high producing animals which were valuable to keep in the herd. Serologic tests however showed agglutinins for *Brucella abortus* in dilutions of 1:50 to 1:500. Further examinations revealed that ten such animals eliminated the organisms in their milk and hence should be classed as "carriers."

The author found that the inoculation of guinea pigs is slightly more efficient as a means of examining milk for *Brucella abortus* than the Petri plate method.

A.C.F.

II. Further Studies of the Influence of Different Levels of Fat Intake Upon Milk Secretion. L. A. MAYNARD, C. M. MCCAY, H. H. WILLIAMS AND L. L. MADSEN, Cornell Univ. Agr. Exp. Station, Ithaca, N. Y. Cornell Agr. Exp. Sta. Bul., *593*, April, 1934.

In studies with milking cows, 4 per cent fat level in the grain mixture has been compared with levels ranging between 6.5 and 7 per cent. No evidence was obtained that the level of fat intake has any influence on the percentage of fat in the milk.

P.H.T.

The Use of Chlorin Products as Germicides on Dairy Farms. W. G. LOVELESS, Dept. of Dairy Husb., Vt. Agr. Exp. Sta., Burlington, Vt. Vt. Agr. Exp. Sta. Bul. *369*, April, 1934.

This bulletin gives information of special value in the use of chlorine solutions on the farm.

A.C.F.

Milk Contamination and the Methylene Blue Reduction Test. N. R. THORNTON, N. J. STRYNADKA, AND F. W. WOOD, Dept. of Dairying,

Univ. of Alberta, Canada, and C. ELLINGER, Dairy Supervisor, Board of Health, City of Edmonton, Alberta, Canada. Can. Public Health J. *25*, 6, p. 284, 1934.

Experimental work was conducted to determine the comparative importance of the different sources of milk contamination on the farm in terms of the methylene blue reduction test.

Twenty farms were selected, the majority of which were having difficulty in maintaining the standard set by the city of Edmonton for milk shipped to milk plants for pasteurization. The regulation requires a minimum reduction period of 5.5 hours as indicated by the methylene blue reduction test.

Bacteriological surveys of the milk production methods showed that the only factors which, singly or in combination, were invariably the major cause of difficulty in maintaining the 5.5 hour standard were: (a) Utensil contamination, (b) Lack of adequate cooling of the milk, and (c) Pathological or abnormal milk.

The authors emphasize utensil contamination as the most important factor and state that there is need for a simple, efficient, and inexpensive method of applying disinfection to milk utensils on the farm. Data are presented to show that contamination from the utensils varies with the temperature at which the utensils were kept between milkings. Milk cans kept "indoors" (warm) were found to contaminate the milk to a much greater extent than those kept "outdoors" (cool). Inadequate cooling was the cause of poor quality in only 3 cases when night's milk was above 55° F. in the morning.

Under the conditions prevailing in the milk shed, the covered (small-top) milk pail was found to be a negligible factor in protecting milk from bacterial contamination.

The authors conclude that "while mastitis or other abnormal milk may cause the reduction of methylene blue in herd milk in 5.5 hours or less, this probably infrequently happens except under very careless herd management and in any case such milk should never be mixed with a city milk supply."

A.C.F.

The Value of the Recording Ultraviolet Meter in the Irradiation of Milk. G. C. SUPPLEE, Bainbridge, N. Y., and H. C. RENTSCHLER, Bloomfield, N. J. Medical Record *142*, Sept. 18 and Oct. 2, 1935.

The development has been announced of an ultra-violet ray recording meter for the accurate control of irradiation of milk. This instrument and its application were worked out by Dr. H. C. Rentschler of the Westinghouse reesarch laboratories and Dr. G. C. Supplee of the Borden Company. It is a final step in checking the potency of irradiated milk during irradiation, thus determining immediately whether the efficiency of the process is up to standard. It is analogous in the principle of its application to the recording thermometer on a pasteurizer.

C.J.B.

Survey of Consumer Buying Habits Reveals Our Advertising, Sales Policies Need a "Shake-Up." P. O. NARVESON, Los Angeles, California. The Milk Dealer, *24*, 8, p. 34, May, 1935.

A survey of the buying habits of fresh-milk consumers made through calls on 2,000 typical homes in 11 southern California districts indicates that consumers want richer milk, holding that feature more vital than many others that are more important. They also want better taste and flavor, which they seem to associate with raw milk.

The average consumer does not appreciate the dietary value and sanitary quality of milk. For cooking they use "canned milks," probably because it has been "sold" to them. In general the survey indicates that consumers regard for fresh milk is affected by advertising. They have heard about children's need for milk so they give it to the youngsters but don't use it themselves. They have a feeling that "natural" milk is best, probably from certified milk advertising and from childhood associations. C.J.B.

Iodized Milk and the Human Diet. ORMSBY MCHARG, I–O Products, Inc., Milwaukee, Wisconsin. The Milk Dealer, *24*, 7, p. 76, April, 1935.

The article discusses the need of organic iodine in the human diet. Two ways of producing an iodine content in milk are discussed. The most desirable way, because it helps the cow and her offspring, is to incorporate an organic iodine in the cow's feed. The other way is to add the organic iodine to her milk while in the pasteurization tank, stirring the contents so as to insure a uniform mix.

Feeding enough organic iodine to cows with their dry feed or in their water supply will produce any desired number of parts of pure organic iodine per billion in their milk. Repeated tests where a five per cent organic iodine solution was fed to cows at the rate of one gallon to 10 tons of dry feed, and where the average cow has been fed 10 pounds of this dry feed per day, have produced in the milk an iodine content of approximately 900 parts per billion. Approximately 20 per cent of the iodine fed to cows recurs in their milk in pure organic form. C.J.B.

New Lactometers for Use in Routine Milk Analysis. DAVID WILBUR HORN, Bryn Mawr, Pa. The Milk Dealer, *24*, 11, p. 33, August, 1935.

The author has introduced a rational lactometer (so-called for the lack of suggestion of a better name). Some unsuspected weaknesses of current forms of lactometers are brought out. A description is given of a modification of the rational lactometer enabling the operator to read total solids at once and to obtain solids-not-fat directly, by the use of the simplest mental arithmetic. C.J.B.

The Nutritive Value of Lactose in Man. ALFRED E. KOEHLER, IONE RAPP AND ELSIE HILL, Santa Barbara Cottage Hospital and the Sansum Clinic, Santa Barbara, California. J. Nutrition *9*, p. 715, June, 1935.

The ingestion of 1.5 g. of lactose per kilo in normal subjects did not cause any marked change in the blood sugar level but lactosuria frequently resulted. In diabetics the ingestion of lactose caused a rise in blood sugar of nearly the same magnitude as did glucose, but lactosuria was not noted. Lactose ingestion caused a slight rise in the blood sugar of obese subjects. The average recovery, in the urine, of injected lactose was the same (89 to 93 per cent) in normal, diabetic, or obese subjects. Ingested lactose caused a small drop in blood inorganic phosphorus. L.A.M.

The Effects of Lactose on Growth and Longevity. E. O. WHITTIER, C. A. CARY AND N. R. ELLIS, Labs. and Animal Husbandry Div. Bur. of Animal Ind., U. S. Dept. of Agri., Washington, D. C. J. of Nutrition *9*, p. 521, April, 1935.

With diets containing 30 per cent of lactose or of sucrose, the lactose diet caused more rapid increase in weight in young rats and a longer average life. With *ad libitum* feeding the animals on the sucrose diet became much heavier than those on the lactose diet, primarily because of a larger fat storage which was attributed to a larger food intake. Pigs fed sucrose accumulated a greater proportion of fat than did those fed lactose. The characteristic effect of lactose was evidently not due to stimulation of the growth of acidophilic organisms, since dextrin did not have the same effect as lactose. Diets containing 45.0 and 63.5 per cent of lactose caused diarrhea whereas similar levels of sucrose were tolerated. L.A.M.

Ultra-Violet Rays Now Go to Work in Dairies. L. V. BURTON, Editor of Food Ind., McGraw-Hill Co., New York, N. Y. Food Ind., *6*, 8, p. 342, August, 1934.

A brief history of the discovery of the processes of producing vitamin D milk is given, the equipment for irradiating is described and illustrated, costs of production are considered, and some experiences in competitive distribution are discussed. J.C.P.

What Every Person Should Know About Milk. LESLIE C. FRANK, Sanitary Engineer in Charge, Office of Milk Investigations, U. S. Public Health Service, Washington, D. C. Milk Dealer, *23*, 10, p. 86, July, 1934.

This is a general statement of the food value of milk. No new information is given, although quotations are included from some of the recognized authorities. The author predicts that some time in the future grade A milk

may be required to have been produced by cows receiving at least a standard balanced ration so their milk may possess the maximum food value for human beings. J.C.P.

The Influence of Vitamin D in the Prevention of Dental Caries. P. G. ANDERSON, C. H. M. WILLIAMS, H. HALDERSON, C. SUMMERFELDT, AND R. C. AGNEW. Am. Dent. Assn., *21*, p. 1349, Aug., 1934.

The influence of vitamin D on the incidence of dental caries was investigated by placing 87 children, from 2 to 16 years of age, on a diet containing vitamin D in the form of viosterol, and comparing them with 75 not receiving extra vitamin D. The regular diet of all the children consisted of milk, meat, vegetables, fruits and cereals. The vitamin D was incorporated in the form of 8 drops of 250 D viosterol in a ginger cookie. Results showed that the addition of this form of vitamin D brought about a striking decrease in dental caries in the children in the age group from 3 to 10 years, but that the reduction was not statistically significant in those from 11 to 16 years of age. The conclusion is that added vitamin D decreases dental caries in children living under good hygienic and dietetic conditions. J.A.T.

Effectiveness of Vitamin D in Infancy in Relation to the Vitamin Source. P. C. JEANS AND G. STEARNS. Proc. Soc. Exp. Biol. and Med. *31*, p. 1159, 1934.

Studies on seven infants, three from 5 to 8 weeks of age, three from 16 to 24 weeks, and one a year old, show that the calcium retention per kilogram of body weight was about the same when each in turn was given formulas made from irradiated evaporated milk containing 50 Steenbock units of vitamin D, evaporated milk to which a concentrate of cod liver oil containing 150 units had been added, and evaporated milk supplemented with cod liver oil containing 40 units per gram.

Committee comments: The authors convey the idea that this article is a preliminary report. A.C.F.

Clinical Experience with Vitamin D Milks. J. M. LEWIS. N. Y. State Jour. Med. *34*, p. 685, Aug. 1, 1934.

Investigations of the incidence of rickets show that from 50 to 60 per cent of infants in New York City display evidence of clinical rickets in the winter, and that in 10 per cent of the white and 20 per cent of the colored babies rickets is severe. Since milk is the universal food for infants, it is logical to enrich it in vitamin D, thus providing automatic protection against this widespread disease.

When Vitamin D milk is employed, a smaller number of units is required than in the case of other antirachitics. Irradiated milk is protective when

42 rat units of vitamin D are fed daily, whereas 600 units are needed when viosterol is used, and cod liver oil must furnish 160 units. Vitamin D milk from cows fed on irradiated yeast is effective in the control of rickets when 24 ounces containing 160 rat units per liter are given daily. These results have been shown by clinical tests on 202 infants, carried out by the author and the late Dr. A. F. Hess.

Milk containing 80 units of crystalline vitamin D, isolated from ergosterol, has also displayed marked antirachitic properties, but poorer results were achieved when this crystalline vitamin D was dissolved in oil, a fact proving again that milk is the ideal medium for vitamin D. J.A.T.

Infant Nutrition: Some Principles for Infants and Adults. J. R. GERSTLEY. Ill. Med. J., *66*, p. 280. Sept., 1934.

The addition of at least 12 per cent lactose to cow's milk for infant feeding results in a favorable change in the intestinal flora from a type in which colon bacillus predominates to a gram positive type in which bifidus acidophilus organisms predominate, as in breast fed infants. The stools are acid and resemble those of breast fed infants. About two weeks should be allowed for the change in intestinal flora to occur. The addition of suitable amounts of lactose to the adult diet will establish an intestinal flora favorable to the growth of acidophilus organisms and inhibitive to the putrefactive type. J.A.T.

Breast and Artificial Feeding. CLIFFORD G. GRULEE, Rush Medical College, Chicago, Illinois. HEYWORTH N. SANFORD, Infant Welfare Society, Chicago, Illinois. PAUL H. HERRON, Spokane, Washington. J. Am. Med. Assoc., *103*, 10, p. 735, Sept. 8, 1934.

In a study of 20,061 infants from birth to 9 months of age, 48.5 per cent were totally breast-fed, 43.0 per cent were partially breast-fed, and 8.5 per cent were artificially fed. The total morbidity of the breast-fed group was 37.4 per cent, of the partially breast-fed group 53.8 per cent, and of the artificially fed group 63.6 per cent.

The average mortality of these infants per year was 1.1 per cent. Of this mortality, 6.7 per cent were in the breast-fed group, 27.2 per cent in the partially breast-fed group, and 66.1 per cent in the artificially fed group. A.C.F.

Producing Homogenized Vitamin D Milk. ARTHUR G. WEIGOLD, Manager, Torrington Creamery Inc., Torrington, Connecticut. Milk Dealer, *23*, 12, p. 32, Sept., 1934.

The author relates his experiences in producing homogenized milk, the cost of which was found to be $0.009 or nearly one per cent per quart for

depreciation, power, and labor. If a larger volume were handled, this cost would be reduced considerably.

During the past year the creamery has placed homogenized vitamin D milk on the market and has found it to be satisfactory, sales increasing from this type of milk each week. Several cases are cited where the homogenized milk was found to be very valuable in the feeding of infants. J.C.P.

Vitamin D in the Blood and Milk of Cows Fed Irradiated Yeast. R. F. LIGHT, L. T. WILSON AND C. N. FREY, Fleischman Laboratories, New York and Walker-Gordon Laboratory Co., Inc., Plainsboro, N. J. J. Nutrition, *8*, 105, 1934.

The work of Sure (J. Biol. Chem. 76, 685, 1929) has shown that probably less than 30 per cent of the vitamin B ingested is secreted in the milk of rats. Fraps and Treichler (Ind. and Eng. Chem. 24, 1079, 1932) has shown that the vitamin A content of milk may range from 75 to 2000 units per quart depending upon the vitamin A content of the feed.

According to Hess *et al.* (J. Biol. Chem. 97, 369, 1932) the vitamin D potency of butterfat is inversely proportional to the per cent fat in the milk and nearly directly proportional to the amount of vitamin D fed.

The data presented in this paper indicate that practically all of the vitamin D ingested is absorbed in the blood stream although the major portion is destroyed in the body. The destruction is more rapid than heretofore suspected. The secretion of vitamin A and D respectively into milk is similar in that 2 to 3 per cent of the ingested vitamins is secreted into the milk. They differ however in that vitamin A appears to be more stable in the body and much of its excess is stored in the liver. G.E.H.

Storage of Vitamin A in Cattle. H. R. GUILBERT AND G. H. HART, Col. of Agr., Univ. of California, Davis, California. J. Nutrition, *8*, 25, 1934.

In previous work Hart *et al.* have shown that cattle on the range in California are subject to a low vitamin intake during the dry season. Two steers on a ration of dried molasses beet pulp, rolled barley, cottonseed meal and calcium carbonate showed clinical symptoms of vitamin A deficiency. At 282 days of feeding they were in critical condition.

On restricted vitamin A diets the milk of the dams was deficient or subnormal in vitamin A. The calves from heifers having a restricted vitamin A diet during gestation developed a severe diarrhea at 2 to 8 days of age.

The manifestations of vitamin A deficiency under natural conditions on the range, previously reported, have thus been produced under controlled conditions. G.E.H.

MISCELLANEOUS

A Study of the Composition of Boiler Water. Parts I and II. J. L. Bray, Purdue Univ., West Lafayette, Ind. The Milk Dealer, *24*, 5, p. 32, Feb., 1935; No. 6, p. 40, March, 1935.

Part I. The writer feels safe in saying that over 90 per cent of the boiler failures with which he has been concerned can be traced to one cause—embrittlement of the metal and that in turn to the composition of the boiler water. Such a failure characteristically starts between rivets, usually on a longitudinal seam, although sometimes on a girth seam, as a hair-line crack.

When water of "temporary" hardness is brought to boiling, the carbonates precipitate out, may be removed, and thus render the water soft. When the hardness of the water is of a permanent character, there are available two methods of softening, the lime-soda process and the zeolite process. In the lime-soda process calcium hydroxide is used to remove calcium and magnesium carbonates and bicarbonates and soda ash to remove the sulphates. The calcium and magnesium are removed; only relatively small amounts of sodium sulphate and carbonate are present and these, after prolonged use of the boiler, tend to form an easily removed scale. In the zeolite method of softening, while the calcium and magnesium are removed, their places are taken by similar sodium salts or, strictly speaking, the calcium and magnesium are replaced, not removed.

Part II. The possible causes of boiler failure are listed as follows: (a) material, (b) workmanship, (c) condition of operation, and (d) character of boiler water. The author minimizes the first three causes but stresses the importance of character of boiler water. In the opinion of the author, particularly in hard-water districts, it is the most common reason for failure.

Tabulations of the composition of the feed waters used in boilers that have failed through embrittlement show a very low sodium sulphate to alkalinity-as-sodium carbonate ratio. Hard waters used in boilers which did not show embrittlement showed a relatively high ratio existing between these constituents. Laboratory tests showed that failure always occurred when the above ratio is low, seldom if ever occurred when it is high.

The necessity of keeping this ratio within certain limits is now recognized in the adoption of a boiler code by the American Society of Mechanical Engineers which calls for a definite relationship between this ratio and steam pressure, as follows:

STEAM PRESSURE—LBS. PER SQUARE INCH	RELATION OF SODIUM CARBONATE ALKALINITY	TO SODIUM SULPHATE
0 to 150	1	1
150 to 250	1	2
250 and over	1	3

In using water of temporary hardness, as we add make-up water the carbonates of calcium and magnesium, together with some sulphates, precipitate out in the form of a light, fluffy, and easily removed scale. However, the salts of sodium are soluble and gradually build up in solution until the boiler water becomes very alkaline without the necessary sulphate to protect it. These are the very conditions for embrittlement. If zeolite softening is used, the same condition is brought about—the substitution of sodium salts for those of calcium and magnesium. Even with the lime-soda treatment the condition might come about, but much more slowly.

The following conclusions are drawn: 1. Watch the sodium sulphate to alkalinity-as-sodium carbonate ratio in boiler water. The composition of the feed water while significant is not vital, for it is the composition of the water that comes in contact with the boiler metal that is important. 2. Analyze the boiler water at regular and fairly frequent intervals and when the requisite ratio is exceeded take steps to adjust it either by suitable additions or blow out the boiler and start over. 3. Be careful in using waters of temporary hardness. While these may appear attractive from an operating standpoint and often are not harmful, the changes taking place in the boiler may bring about a very dangerous condition. 4. Either process of water softening may be used, for both possess certain advantages but must be accompanied by constant analyses to avoid building up harmful salts. 5. Avoid outside-caulked boilers and do not allow the repairmen to caulk leaky boilers from the outside. While this method of repair is easier and cheaper, it permits concentration to take place in the space between the plates of the seam. The safe ratio may not be exceeded in the main body of the boiler water, yet it may be exceeded in this confined space through evaporation and lack of circulation. Solid caustic has actually been found in such seams. C.J.B.

The Common Refrigerants. J. S. Beamensderfer, York Ice Machinery Co., York, Pa. Ind. Eng. Chem., *27*, p. 1027, Sept., 1935.

A review of the characteristics and performance of the chemicals commonly used as refrigerants. The importance of a study of their properties in connection with compressor, condenser and evaporator design is emphasized. The chemicals discussed include carbon dioxide, ammonia, Freon, methyl chloride, sulfur dioxide, F–11, methylene chloride, and water. J.H.N.

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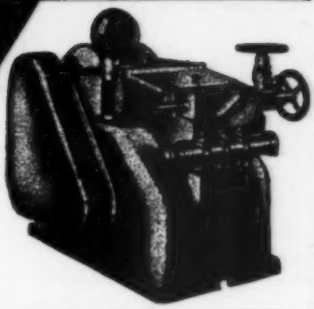

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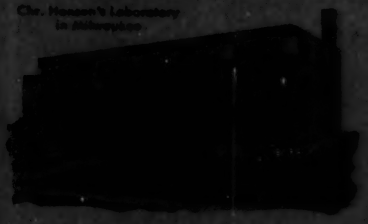

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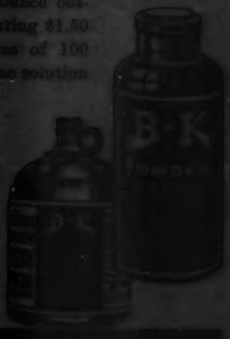

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